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1.1 Overview

A **Host** is a server that has the ability to run Virtual Machines and that is connected to OpenNebula’s Front-end server. OpenNebula can work with Hosts with a heterogeneous configuration, i.e. you can connect Hosts to the same OpenNebula with different hypervisors or Linux distributions. To learn how to prepare the hosts you can read the Node Installation guide.

**Clusters** are pools of hosts that share datastores and virtual networks.

1.1.1 How Should I Read This Chapter

In this chapter there are four guides describing these objects.

- **Host Management**: Host management is achieved through the `onehost` CLI command or through the Sunstone GUI. You can read about Host Management in more detail in the *Managing Hosts* guide.

- **Cluster Management**: Hosts can be grouped in Clusters. These Clusters are managed with the `onecluster` CLI command, or through the Sunstone GUI. You can read about Cluster Management in more detail in the *Managing Clusters* guide.

- **Scheduler**: Where you’ll learn how to change the scheduling configuration to suit your needs. For example changing the scheduling policies or the number of VMs that will be sent per host.

- **Datastore**: Where you’ll learn about how to configure and manage the different types of datastore types.

You should read all the guides in this chapter to familiarize with these objects. For small and homogeneous clouds you may not need to create new clusters.

1.1.2 Hypervisor Compatibility

These guides are compatible with all hypervisors.

**Note**: Linux hosts will be mentioned when the information is applicable to LXD and KVM

1.2 Hosts

In order to use your existing physical nodes, you have to add them to the system as OpenNebula Hosts. To add a host only its hostname and type is needed. Hosts are usually organized in Clusters, you can read more about it in the
Warning: Before adding a Linux host check that you can ssh to it without being prompt for a password.

1.2.1 Create and Delete Hosts

Hosts are the servers managed by OpenNebula responsible for Virtual Machine execution. To use these hosts in OpenNebula you need to register them so they are monitored and made available to the scheduler.

Creating a host:

```
$ onehost create host01 --im kvm --vm kvm
```

ID: 0

The parameters are:
- `--im/-i`: Information Manager driver.
- `--vm/-v`: Virtual Machine Manager driver.

To remove a host, just like with other OpenNebula commands, you can either specify it by ID or by name. The following commands are equivalent:

```
$ onehost delete host01
$ onehost delete 0
```

1.2.2 Showing and Listing Hosts

To display information about a single host the `show` command is used:

```
HOST 0 INFORMATION
ID : 0
NAME : server
CLUSTER : server
STATE : MONITORED
IM_MAD : kvm
VM_MAD : kvm
LAST MONITORING TIME : 05/28 00:30:51

HOST SHARES
TOTAL MEM : 7.3G
USED MEM (REAL) : 4.4G
USED MEM (ALLOCATED) : 1024M
TOTAL CPU : 400
USED CPU (REAL) : 28
USED CPU (ALLOCATED) : 100
TOTAL VMS : 1

LOCAL SYSTEM DATASTORE #0 CAPACITY
TOTAL: : 468.4G
USED: : 150.7G
FREE: : 314.7G

MONITORING INFORMATION
ARCH="x86_64"
```
WILD VIRTUAL MACHINES

<table>
<thead>
<tr>
<th>NAME</th>
<th>IMPORT_ID</th>
<th>CPU</th>
<th>MEMORY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The information of a host contains:

- General information of the hosts including its name and the drivers used to interact with it.
- Capacity information (Host Shares) for CPU and memory.
- Local datastore information (Local System Datastore) if the Host is configured to use a local datastore (e.g. Filesystem in ssh transfer mode).
- Monitoring Information, including PCI devices
- Virtual Machines actives on the hosts. Wild are virtual machines actives on the host but not started by OpenNebula, they can be imported into OpenNebula.

To see a list of all the hosts:

```bash
$ onehost list
```

<table>
<thead>
<tr>
<th>ID</th>
<th>NAME</th>
<th>CLUSTER</th>
<th>RVM</th>
<th>ALLOCATED_CPU</th>
<th>ALLOCATED_MEM</th>
<th>STAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>server</td>
<td>server</td>
<td>1</td>
<td>100 / 400 (25%)</td>
<td>1024M / 7.3G (13%)</td>
<td>on</td>
</tr>
<tr>
<td>1</td>
<td>kvm1</td>
<td>kvm</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>off</td>
</tr>
<tr>
<td>2</td>
<td>kvm2</td>
<td>kvm</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>off</td>
</tr>
</tbody>
</table>

The above information can be also displayed in XML format using `–x`.

### 1.2.3 Host Life-cycle: Enable, Disable, Offline and Flush

In order to manage the life cycle of a host it can be set to different operation modes: enabled (on), disabled (dsbl) and offline (off). The different operation status for each mode is described by the following table:
The `onehost` tool includes three commands to set the operation mode of a host: `disable`, `offline` and `enable`, for example:

```bash
$ onehost disable 0
```

To re-enable the host use the `enable` command:

```bash
$ onehost enable 0
```

Similarly to put the host offline:

```bash
$ onehost offline 0
```

The `flush` command will migrate all the active VMs in the specified host to another server with enough capacity. At the same time, the specified host will be disabled, so no more Virtual Machines are deployed in it. This command is useful to clean a host of active VMs. The migration process can be done by a resched action or by a recover delete-recreate action, it can be configured at the `/etc/one/cli/onehost.yaml` by setting the field `default_actions\flush` to `delete-recreate` or to `resched`. Here is an example:

```yaml
;display_actions:
  - :flush: delete-recreate
```

### 1.2.4 Custom Host Tags & Scheduling Policies

The Host attributes are inserted by the monitoring probes that run from time to time on the nodes to get information. The administrator can add custom attributes either creating a probe in the host, or updating the host information with: `onehost update`.

For example to label a host as `production` we can add a custom tag `TYPE`:

```bash
$ onehost update
... TYPE="production"
```

This tag can be used at a later time for scheduling purposes by adding the following section in a VM template:
That will restrict the Virtual Machine to be deployed in TYPE="production" hosts. The scheduling requirements can be defined using any attribute reported by onehost show, see the Scheduler Guide for more information.

This feature is useful when we want to separate a series of hosts or marking some special features of different hosts. These values can then be used for scheduling the same as the ones added by the monitoring probes, as a placement requirement.

### 1.2.5 Update Host Drivers

When OpenNebula monitors a host, it copies driver files to /var/tmp/one. When these files are updated, they need to be copied again to the hosts with the sync command. To keep track of the probes version there’s a file in /var/lib/one/remotes/VERSION. By default this holds the OpenNebula version (e.g. ‘5.0.0’). This version can be seen in the hosts with a onehost show <host>:

```bash
$ onehost show 0
HOST 0 INFORMATION
ID : 0
[...]
MONITORING INFORMATION
VERSION="5.0.0"
[...]
```

The command onehost sync only updates the hosts with VERSION lower than the one in the file /var/lib/one/remotes/VERSION. In case you modify the probes this VERSION file should be modified with a greater value, for example 5.0.0.01.

In case you want to force upgrade, that is, no VERSION checking you can do that adding --force option:

```bash
$ onehost sync --force
```

You can also select which hosts you want to upgrade naming them or selecting a cluster:

```bash
$ onehost sync host01,host02,host03
$ onehost sync -c myCluster
```

Onehost sync command can alternatively use rsync as the method of upgrade. To do this you need to have installed rsync command in the frontend and the nodes. This method is faster that the standard one and also has the benefit of deleting remote files no longer existing in the frontend. To use it add the parameter --rsync:

```bash
$ onehost sync --rsync
```

### 1.2.6 Host Information

Hosts include the following monitoring information. You can use this variables to create custom RANK and REQUIREMENTS expressions for scheduling. Note also that you can manually add any tag and use it also for RANK and REQUIREMENTS.
### Key

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HY-PER-VI-SOR</td>
<td>Name of the hypervisor of the host, useful for selecting the hosts with a specific technology.</td>
</tr>
<tr>
<td>ARCH</td>
<td>Architecture of the host CPU’s, e.g. x86_64.</td>
</tr>
<tr>
<td>MOD-EL-NAME</td>
<td>Model name of the host CPU, e.g. Intel(R) Core(TM) i7-2620M CPU @ 2.70GHz.</td>
</tr>
<tr>
<td>CPUSPEED</td>
<td>Speed in MHz of the CPU’s.</td>
</tr>
<tr>
<td>HOSTNAME</td>
<td>As returned by the <code>hostname</code> command.</td>
</tr>
<tr>
<td>VERSION</td>
<td>This is the version of the monitoring probes. Used to control local changes and the update process.</td>
</tr>
<tr>
<td>MAX_CPU</td>
<td>Number of CPU’s multiplied by 100. For example, a 16 cores machine will have a value of 1600. The value of RESERVED_CPU will be subtracted from the information reported by the monitoring system. This value is displayed as TOTAL CPU by the <code>onehost show</code> command under HOST SHARE section.</td>
</tr>
<tr>
<td>MAX_MEM</td>
<td>Minimum memory that could be used for VMs. It is advised to take out the memory used by the hypervisor using RESERVED_MEM. This values is subtracted from the memory amount reported. This value is displayed as TOTAL MEM by the <code>onehost show</code> command under HOST SHARE section.</td>
</tr>
<tr>
<td>MAX_DISK</td>
<td>Total space in megabytes in the DATASTORE LOCATION.</td>
</tr>
<tr>
<td>USED_CPU</td>
<td>Percentage of used CPU multiplied by the number of cores. This value is displayed as USED CPU (REAL) by the <code>onehost show</code> command under HOST SHARE section.</td>
</tr>
<tr>
<td>USED_MEM</td>
<td>Memory used, in kilobytes. This value is displayed as USED MEM (REAL) by the <code>onehost show</code> command under HOST SHARE section.</td>
</tr>
<tr>
<td>USED_DISK</td>
<td>Space used in megabytes in the DATASTORE LOCATION.</td>
</tr>
<tr>
<td>FREE_CPU</td>
<td>Percentage of idling CPU multiplied by the number of cores. For example, if 50% of the CPU is idling in a 4 core machine the value will be 200.</td>
</tr>
<tr>
<td>FREE_MEM</td>
<td>Usable memory for VMs at that moment, in kilobytes.</td>
</tr>
<tr>
<td>FREE_DISK</td>
<td>Space in megabytes in the DATASTORE LOCATION.</td>
</tr>
<tr>
<td>CPU_USAGE</td>
<td>CPU allocated to VMs running on the host as requested in CPU in each VM template. This value is displayed as USED CPU (ALLOCATED) by the <code>onehost show</code> command under HOST SHARE section.</td>
</tr>
<tr>
<td>MEM_USAGE</td>
<td>Memory allocated to VMs running on the host as requested in MEMORY in each VM template. This value is displayed as USED MEM (ALLOCATED) by the <code>onehost show</code> command under HOST SHARE section.</td>
</tr>
<tr>
<td>DISK_USAGE</td>
<td>Size allocated to disk images of VMs running on the host computed using the SIZE attribute of each image and considering the datastore characteristics.</td>
</tr>
<tr>
<td>NETRX</td>
<td>Received bytes from the network.</td>
</tr>
<tr>
<td>NETTX</td>
<td>Transferred bytes to the network.</td>
</tr>
<tr>
<td>WILD</td>
<td>Comma separated list of VMs running in the host that were not launched and are not currently controlled by OpenNebula.</td>
</tr>
<tr>
<td>ZOMBIES</td>
<td>Comma separated list of VMs running in the host that were launched by OpenNebula but are not currently controlled by it.</td>
</tr>
</tbody>
</table>

### 1.2.7 Importing Wild VMs

The monitoring mechanism in OpenNebula reports all VMs found in a hypervisor, even those not launched through OpenNebula. These VMs are referred to as Wild VMs, and can be imported to be managed through OpenNebula. This includes all supported hypervisors, even the hybrid ones.
The Wild VMs can be spotted through the `onehost show` command:

```bash
$ onehost show 3
HOST 3 INFORMATION
ID : 3
NAME : MyvCenterHost
CLUSTER : -
STATE : MONITORED
[...]
WILD VIRTUAL MACHINES
NAME IMPORT_ID CPU MEMORY
Ubuntu14.04VM 4223f951-243a-b31a-018f-390a02ff5c96 1 2048
CentOS7 422375e7-7fc7-4ed1-e0f0-fb778fe6e6e0 1 2048
```

And imported through the `onehost importvm` command:

```bash
$ onehost importvm 0 CentOS7
$ onevm list
ID USER GROUP NAME STAT UCPU UMEM HOST TIME
3 oneadmin oneadmin CentOS7 runn 0 590M MyvCenterHost 0d 01h02
```

After a Virtual Machine is imported, their life-cycle (including creation of snapshots) can be controlled through OpenNebula. However, some operations cannot be performed on an imported VM, including: poweroff, undeploy, migrate or delete-recreate.

The same import mechanism is available graphically through Sunstone. Running and Powered Off VMs can be imported through the WILDS tab in the Host info tab.

### 1.2.8 Using Sunstone to Manage Hosts

You can also manage your hosts using Sunstone. Select the Host tab, and there, you will be able to create, enable, disable, delete and see information about your hosts in a user friendly way.
1.3 Clusters

A Cluster is a group of *Hosts*. Clusters can have associated Datastores and *Virtual Networks*, this is how the administrator sets which Hosts have the underlying requirements for each Datastore and Virtual Network configured.

1.3.1 Cluster Management

Clusters are managed with the *"onecluster" command*. To create new Clusters, use `onecluster create <name>`. Existing Clusters can be inspected with the `onecluster list` and `show` commands.

```
$ onecluster list
   ID  NAME  HOSTS  NETS  DATASTORES

$ onecluster create production
   ID: 100

$ onecluster list
   ID  NAME  HOSTS  NETS  DATASTORES
   100 production 0 0 0

$ onecluster show production
   CLUSTER 100 INFORMATION
   ID: 100
   NAME: production

   HOSTS

   VNETS

   DATASTORES
```

Add Hosts to Clusters

Hosts can be created directly in a Cluster, using the *--cluster* option of `onehost create`, or be added at any moment using the command `onecluster addhost`. Hosts can be in only one Cluster at a time.

To delete a Host from a Cluster, the command `onecluster delhost` must be used. A Host needs to belong to a Cluster, so it will be moved to the default cluster.
In the following example, we will add Host 0 to the Cluster we created before. You will notice that the `onecluster show` command will list the Host ID 0 as part of the Cluster.

```bash
$ onehost list
  ID  NAME   CLUSTER  RVM  TCPU  FCPU  ACPU  TMEM  FMEM  AMEM  STAT
  0  host01    -      7   400   290   400  3.7G  2.2G  3.7G  on

$ onecluster addhost production host01

$ onehost list
  ID  NAME   CLUSTER  RVM  TCPU  FCPU  ACPU  TMEM  FMEM  AMEM  STAT
  0  host01  production    7   400   290   400  3.7G  2.2G  3.7G  on

$ onecluster show production
CLUSTER 100 INFORMATION
  ID : 100
  NAME : production

  HOSTS
  0

  VNETS

  DATASTORES
```

### Add Resources to Clusters

Datastores and Virtual Networks can be added to multiple Clusters. This means that any Host in those Clusters is properly configured to run VMs using Images from the Datastores, or is using leases from the Virtual Networks.

For instance, if you have several Hosts configured to use a given Open vSwitch network, you would group them in the same Cluster. The Scheduler will know that VMs using these resources can be deployed in any of the Hosts of the Cluster.

These operations can be done with the `onecluster addvnet/delvnet` and `adddatastore/deldatastore`:

```bash
$ onecluster addvnet production priv-ovswitch

$ onecluster adddatastore production iscsi

$ onecluster list
  ID  NAME   HOSTS  NETS  DATASTORES
  100  production    1    1    1

$ onecluster show 100
CLUSTER 100 INFORMATION
  ID : 100
  NAME : production

  CLUSTER TEMPLATE

  HOSTS
  0

  VNETS
  1
```
The System Datastore for a Cluster

In order to create a complete environment where the scheduler can deploy VMs, your Clusters need to have at least one System DS.

You can add the default System DS (ID: 0), or create a new one to improve its performance (e.g. balance VM I/O between different servers) or to use different system DS types (e.g. shared and ssh).

To use a specific System DS with your cluster, instead of the default one, just create it (with TYPE=SYSTEM_DS in its template), and associate it just like any other datastore (onecluster adddatastore).

Cluster Properties

Each cluster includes a generic template where cluster configuration properties or attributes can be defined. The following list of attributes are recognized by OpenNebula:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESERVED_CPU</td>
<td>In percentage. Applies to all the Hosts in this cluster. It will be subtracted from the TOTAL CPU. See scheduler.</td>
</tr>
<tr>
<td>RESERVED_MEM</td>
<td>In KB. Applies to all the Hosts in this cluster. It will be subtracted from the TOTAL MEM. See scheduler.</td>
</tr>
</tbody>
</table>

You can easily update these values with the onecluster update command. Also, you can add as many variables as you want, following the standard template syntax. These variables will be used for now only for informational purposes.

1.3.2 Scheduling and Clusters

Automatic Requirements

When a Virtual Machine uses resources (Images or Virtual Networks) from a Cluster, OpenNebula adds the following requirement to the template:

```
$ onevm show 0
[...]
AUTOMATIC_REQUIREMENTS="CLUSTER_ID = 100"
```

Because of this, if you try to use resources that do not belong to the same Cluster, the Virtual Machine creation will fail with a message similar to this one:

```
$ onetemplate instantiate 0
DISK [0]: IMAGE [0] from DATASTORE [1] requires CLUSTER [101]
NIC [0]: NETWORK [1] requires CLUSTER [100]
```
**Manual Requirements and Rank**

The placement attributes *SCHED_REQUIREMENTS* and *SCHED_RANK* can use attributes from the Cluster template. Let's say you have the following scenario:

$$\text{onehost list}$$

<table>
<thead>
<tr>
<th>ID</th>
<th>NAME</th>
<th>CLUSTER</th>
<th>RVM</th>
<th>ALLOCATED_CPU</th>
<th>ALLOCATED_MEM</th>
<th>STAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>host01</td>
<td>cluster_a</td>
<td>0</td>
<td>0 / 200 (0%)</td>
<td>0K / 3.6G (0%)</td>
<td>on</td>
</tr>
<tr>
<td>2</td>
<td>host02</td>
<td>cluster_a</td>
<td>0</td>
<td>0 / 200 (0%)</td>
<td>0K / 3.6G (0%)</td>
<td>on</td>
</tr>
<tr>
<td>3</td>
<td>host03</td>
<td>cluster_b</td>
<td>0</td>
<td>0 / 200 (0%)</td>
<td>0K / 3.6G (0%)</td>
<td>on</td>
</tr>
</tbody>
</table>

$$\text{onecluster show cluster_a}$$

CLUSTER TEMPLATE

QOS="GOLD"

$$\text{onecluster show cluster_b}$$

CLUSTER TEMPLATE

QOS="SILVER"

You can use these expressions:

- *SCHED_REQUIREMENTS = "QOS = GOLD"*
- *SCHED_REQUIREMENTS = "QOS != GOLD & HYPERVISOR = kvm"*

### 1.3.3 Managing Clusters in Sunstone

The Sunstone UI interface offers an easy way to manage clusters and the resources within them. You will find the cluster sub-menu under the infrastructure menu. From there, you will be able to:

- Create new clusters selecting the resources you want to include in this cluster:

  ![Create Cluster](image)

  - Please select one or more hosts from the list

- See the list of current clusters, from which you can update the template of existing ones, or delete them.
1.4 Scheduler

The Scheduler is in charge of the assignment between pending Virtual Machines and known Hosts. OpenNebula’s architecture defines this module as a separate process that can be started independently of oned (it is however started automatically when you start the opennebula service).

1.4.1 Match-making

OpenNebula comes with a match making scheduler (mm_sched) that implements the Rank Scheduling Policy. The goal of this policy is to prioritize those resources more suitable for the VM.

The match-making algorithm works as follows:

- Each disk of a running VM consumes storage from an Image Datastore. The VMs that require more storage than there is currently available are filtered out, and will remain in the pending state.

- Those hosts that do not meet the VM requirements (see the SCHED_REQUIREMENTS attribute) or do not have enough resources (available CPU and memory) to run the VM are filtered out (see below for more information).

- The same happens for System Datastores: the ones that do not meet the DS requirements (see the SCHED_DS_REQUIREMENTS attribute) or do not have enough free storage are filtered out.

- Finally if the VM uses automatic network selection, the virtual networks that do not meet the NIC requirements (see the SCHED_REQUIREMENTS attribute for NICs) or do not have enough free leases are filtered out.

- The SCHED_RANK and SCHED_DS_RANK expressions are evaluated upon the Host and Datastore list using the information gathered by the monitor drivers. Also the NIC/SCHED_RANK expression are evaluated upon the Network list using the information in the Virtual Network template. Any variable reported by the monitor driver (or manually set in the Host, Datastore or Network template) can be included in the rank expressions.

- Those resources with a higher rank are used first to allocate VMs.

This scheduler algorithm easily allows the implementation of several placement heuristics (see below) depending on the RANK expressions used.
Configuring the Scheduling Policies

The policy used to place a VM can be configured in two places:

- For each VM, as defined by the SCHED_RANK and SCHED_DS_RANK attributes in the VM template. And SCHED_RANK in each VM NIC.
- Globally for all the VMs in the sched.conf file (OpenNebula restart required).

Re-Scheduling Virtual Machines

When a VM is in the running or poweroff state it can be rescheduled. By issuing the onevm resched command the VM’s rescheduling flag is set. In a subsequent scheduling interval, the VM will be consider for rescheduling, if:

- There is a suitable host for the VM.
- The VM is not already running in it.

This feature can be used by other components to trigger rescheduling action when certain conditions are met.

Scheduling VM Actions

Users can schedule one or more VM actions to be executed at a certain date and time. The onevm schedule command will add a new SCHED_ACTION attribute to the Virtual Machine editable template. Visit the VM guide for more information.

1.4.2 Configuration

The behavior of the scheduler can be tuned to adapt it to your infrastructure with the following configuration parameters defined in /etc/one/sched.conf:

- MESSAGE_SIZE: Buffer size in bytes for XML-RPC responses.
- ONE_XMLRPC: URL to connect to the OpenNebula daemon (oned) (Default: http://localhost:2633/RPC2)
- SCHED_INTERVAL: Seconds between two scheduling actions (Default: 30)
- MAX_VM: Maximum number of Virtual Machines scheduled in each scheduling action (Default: 5000). Use 0 to schedule all pending VMs each time.
- MAX_DISPATCH: Maximum number of Virtual Machines actually dispatched to a host in each scheduling action (Default: 30)
- MAX_HOST: Maximum number of Virtual Machines dispatched to a given host in each scheduling action (Default: 1)
- LIVE_RESCHEDS: Perform live (1) or cold migrations (0) when rescheduling a VM
- MEMORY_SYSTEM_DS_SCALE: This factor scales the VM usage of the system DS with the memory size. This factor can be use to make the scheduler consider the overhead of checkpoint files: system_ds_usage = system_ds_usage + memory_system_ds_scale * memory
- DIFFERENT_VNETS: When set (YES) the NICs of a VM will be forced to be in different Virtual Networks.

The default scheduling policies for hosts, datastores and virtual networks are defined as follows:

- DEFAULT_SCHED: Definition of the default scheduling algorithm.
  - RANK: Arithmetic expression to rank suitable hosts based on their attributes.
  - POLICY: A predefined policy, it can be set to:
### POLICY DESCRIPTION

<table>
<thead>
<tr>
<th>POLICY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td><strong>Packing</strong>: Minimize the number of hosts in use by packing the VMs in the hosts to reduce VM fragmentation</td>
</tr>
<tr>
<td>1</td>
<td><strong>Striping</strong>: Maximize resources available for the VMs by spreading the VMs in the hosts</td>
</tr>
<tr>
<td>2</td>
<td><strong>Load-aware</strong>: Maximize resources available for the VMs by using those nodes with less load</td>
</tr>
<tr>
<td>3</td>
<td><strong>Custom</strong>: Use a custom RANK</td>
</tr>
<tr>
<td>4</td>
<td><strong>Fixed</strong>: Hosts will be ranked according to the PRIORITY attribute found in the Host or Cluster template</td>
</tr>
</tbody>
</table>

- **DEFAULT_DS_SCHED**: Definition of the default storage scheduling algorithm.
  - RANK: Arithmetic expression to rank suitable **datastores** based on their attributes.
  - POLICY: A predefined policy, it can be set to:

<table>
<thead>
<tr>
<th>POLICY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td><strong>Packing</strong>: Tries to optimize storage usage by selecting the DS with less free space</td>
</tr>
<tr>
<td>1</td>
<td><strong>Striping</strong>: Tries to optimize I/O by distributing the VMs across datastores</td>
</tr>
<tr>
<td>2</td>
<td><strong>Custom</strong>: Use a custom RANK</td>
</tr>
<tr>
<td>3</td>
<td><strong>Fixed</strong>: Datastores will be ranked according to the PRIORITY attribute found in the Datastore template</td>
</tr>
</tbody>
</table>

- **DEFAULT_NIC_SCHED**: Definition of the default virtual network scheduling algorithm.
  - RANK: Arithmetic expression to rank suitable **networks** based on their attributes.
  - POLICY: A predefined policy, it can be set to:

<table>
<thead>
<tr>
<th>POLICY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td><strong>Packing</strong>: Tries to pack address usage by selecting the virtual networks with less free leases</td>
</tr>
<tr>
<td>1</td>
<td><strong>Striping</strong>: Tries to distribute address usage across virtual networks</td>
</tr>
<tr>
<td>2</td>
<td><strong>Custom</strong>: Use a custom RANK</td>
</tr>
<tr>
<td>3</td>
<td><strong>Fixed</strong>: Networks will be ranked according to the PRIORITY attribute found in the Network template</td>
</tr>
</tbody>
</table>

The optimal values of the scheduler parameters depend on the hypervisor, storage subsystem and number of physical hosts. The values can be derived by finding out the max number of VMs that can be started in your set up with out getting hypervisor related errors.

Sample Configuration:

```plaintext
MESSAGE_SIZE = 1073741824
ONE_XMLRPC = "http://localhost:2633/RPC2"
SCHED_INTERVAL = 30
MAX_VM = 5000
MAX_DISPATCH = 30
MAX_HOST = 1
LIVE_RESCHEDS = 0
DEFAULT_SCHED = [
    policy = 3,
    rank = "-(RUNNING_VMS * 50 + FREE_CPU)"
]
```

1.4. Scheduler
DEFAULT_DS_SCHED = [  
    policy = 1  
]
DEFAULT_NIC_SCHED = [  
    policy = 1  
]
MEMORY_SYSTEM_DS_SCALE = 0
DIFFERENT_VNETS = YES

Pre-defined Placement Policies

The following list describes the predefined policies (DEFAULT_SCHED) that can be configured through the sched.conf file.

Packing Policy

- **Target**: Minimize the number of cluster nodes in use
- **Heuristic**: Pack the VMs in the cluster nodes to reduce VM fragmentation
- **Implementation**: Use those nodes with more VMs running first
  
  \[
  \text{RANK} = \text{RUNNING\_VMS}
  \]

Striping Policy

- **Target**: Maximize the resources available to VMs in a node
- **Heuristic**: Spread the VMs in the cluster nodes
- **Implementation**: Use those nodes with less VMs running first
  
  \[
  \text{RANK} = \text{"-\ RUNNING\_VMS"}
  \]

Load-aware Policy

- **Target**: Maximize the resources available to VMs in a node
- **Heuristic**: Use those nodes with less load
- **Implementation**: Use those nodes with more FREE\_CPU first
  
  \[
  \text{RANK} = \text{FREE\_CPU}
  \]

Fixed Policy

- **Target**: Sort the hosts manually
- **Heuristic**: Use the PRIORITY attribute
• **Implementation**: Use those nodes with more PRIORITY first

| RANK = PRIORITY |

**Pre-defined Storage Policies**

The following list describes the predefined storage policies (DEFAULT_DS_SCHED) that can be configured through the `sched.conf` file.

**Packing Policy**

Tries to optimize storage usage by selecting the DS with less free space

- **Target**: Minimize the number of system datastores in use
- **Heuristic**: Pack the VMs in the system datastores to reduce VM fragmentation
- **Implementation**: Use those datastores with less free space first

| RANK = "- FREE_MB" |

**Striping Policy**

- **Target**: Maximize the I/O available to VMs
- **Heuristic**: Spread the VMs in the system datastores
- **Implementation**: Use those datastores with more free space first

| RANK = "FREE_MB" |

**Fixed Policy**

- **Target**: Sort the datastores manually
- **Heuristic**: Use the PRIORITY attribute
- **Implementation**: Use those datastores with more PRIORITY first

| RANK = PRIORITY |

**VM Policies**

VMs are dispatched to hosts in a FIFO fashion. You can alter this behavior by giving each VM (or the base template) a priority. Just set the attribute `USER_PRIORITY` to sort the VMs based on this attribute, and so alter the dispatch order. The `USER_PRIORITY` can be set for example in the VM templates for a user group if you want prioritize those templates. Note that this priority is also used for rescheduling.
1.4.3 Limiting the Resources Exposed by a Host

Prior to assigning a VM to a Host, the available capacity is checked to ensure that the VM fits in the host. The capacity is obtained by the monitor probes. You may alter this behavior by reserving an amount of capacity (MEMORY and CPU). You can reserve this capacity:

- Cluster-wise, by updating the cluster template (e.g. `onecluster update`). All the host of the cluster will reserve the same amount of capacity.
- Host-wise, by updating the host template (e.g. `onehost update`). This value will override those defined at cluster level.

In particular the following capacity attributes can be reserved:

- `RESERVED_CPU` in percentage. It will be subtracted from the `TOTAL CPU`
- `RESERVED_MEM` in KB. It will be subtracted from the `TOTAL MEM`

Note: These values can be negative, in that case you’ll be actually increasing the overall capacity so overcommitting host capacity.

1.5 Datastores

OpenNebula features three different datastore types:

- The **Images Datastore**, stores the images repository.
- The **System Datastore** holds disk for running virtual machines, copied or cloned from the Images Datastore.
- The **Files & Kernels Datastore** to store plain files.

1.5.1 Datastore Management

Datastores are managed with the ``onedatastore`` command. In order to be operational an OpenNebula cloud needs at least one Image Datastore and one System Datastore.

Datastore Definition

A datastore definition includes specific attributes to configure its interaction with the storage system; and common attributes that define its generic behavior.

The specific attributes for System and Images Datastores depends on the storage:

- Define Filesystem Datastores.
- Define LVM Datastores.
- Define Ceph Datastores.
- Define Raw Device Mapping Datastores.
- Define iSCSI - Libvirt Datastores.

Also, there are a set of common attributes that can be used in any datastore and compliments the specific attributes for each datastore type described above for each datastore type.
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESTRICTED_DIRS</td>
<td>Paths that can not be used to register images. A space separated list of paths.</td>
</tr>
<tr>
<td>SAFE_DIRS</td>
<td>If you need to un-block a directory under one of the RESTRICTED_DIRS. A space separated list of paths.</td>
</tr>
<tr>
<td>NO_DECOMPRESS</td>
<td>Do not try to untar or decompress the file to be registered. Useful for specialized Transfer Managers</td>
</tr>
<tr>
<td>LIMIT_TRANSFER_BW</td>
<td>Specify the maximum transfer rate in bytes/second when downloading images from a http/https URL. Suffixes K, M or G can be used.</td>
</tr>
<tr>
<td>DATASTORE_CAPACITY_CHECK</td>
<td>The available capacity of the datastore is checked before creating a new image</td>
</tr>
<tr>
<td>LIMIT_MB</td>
<td>The maximum capacity allowed for the datastore in MB.</td>
</tr>
<tr>
<td>BRIDGE_LIST</td>
<td>Space separated list of hosts that have access to the storage to add new images to the datastore.</td>
</tr>
<tr>
<td>STAGING_DIR</td>
<td>Path in the storage bridge host to copy an Image before moving it to its final destination. Defaults to /var/tmp.</td>
</tr>
<tr>
<td>DRIVER</td>
<td>Specific image mapping driver enforcement. If present it overrides image DRIVER set in the image attributes and VM template.</td>
</tr>
<tr>
<td>COMPATIBLE_SYS_DS</td>
<td>Only for IMAGE_DS. Specifies which system datastores are compatible with an image datastore by ID. Ex: “0,100”</td>
</tr>
</tbody>
</table>

The Files & Kernels Datastore is an special datastore type to store plain files to be used as kernels, ram-disks or context files. See here to learn how to define them.

### 1.5.2 Multiple System Datastore Setup

In order to distribute efficiently the I/O of the Virtual Machines across different disks, LUNs or several storage back-ends, OpenNebula is able to define multiple System Datastores per cluster. Scheduling algorithms take into account disk requirements of a particular VM, so OpenNebula is able to pick the best execution host based on capacity and storage metrics.

#### Configuring Multiple Datastores

When more than one System Datastore is added to a cluster, all of them can be taken into account by the scheduler to place Virtual Machines into. System wide scheduling policies are defined in /etc/one/sched.conf. The storage scheduling policies are:

- **Packing**. Tries to optimize storage usage by selecting the Datastore with less free space.
- **Striping**. Tries to optimize I/O by distributing the Virtual Machines across Datastores.
- **Custom**. Based on any of the attributes present in the Datastore template.

To activate for instance the Stripping storage policy, /etc/one/sched.conf must contain:

```bash
DEFAULT_DS_SCHED = [  
  policy = 1
]
```

These policies may be overriden in the Virtual Machine Template, and so apply specific storage policies to specific Virtual Machines.
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
</table>
| SCHED_DS_REQUIREMENTS | Boolean expression to select System Datastores (evaluates to true) to run a VM. | SCHED_DS_REQUIREMENTS="ID=100"  
SCHED_DS_REQUIREMENTS="NAME=GoldenDS"  
SCHED_DS_REQUIREMENTS=FREE_MB > 250000 |
| SCHED_DS_RANK | Arithmetic expression to sort the suitable datastores for this VM. | SCHED_DS_RANK= FREE_MB  
SCHED_DS_RANK=-FREE_MB |

After a VM is deployed in a System Datastore, the admin can migrate it to another System Datastore. To do that, the VM must be first powered-off. The command `onevm migrate` accepts both a new Host and Datastore id, that must have the same TM_MAD drivers as the source Datastore.

**Warning:** Any Host belonging to a given cluster **must** be able to access any System or Image Datastore defined in that cluster.

**Warning:** Admins rights grant permissions to deploy a virtual machine to a certain datastore, using ‘onevm deploy’ command.

### 1.5.3 Disable a System Datastore

System Datastores can be disabled to prevent the scheduler from deploying new Virtual Machines in them. Datastores in the **disabled** state and monitored as usual, and the existing Virtual Machines will continue to run in them.

```bash
$ onedatastore disable system -v  
DATASTORE 0: disabled  

$ onedatastore show system  
DATASTORE 0 INFORMATION  
ID : 0  
NAME : system  
STATE : DISABLED  
```

### 1.6 NUMA and CPU Pinning

#### 1.6.1 Overview

In this guide you’ll learn to setup OpenNebula to control how VM resources are mapped onto the hypervisor ones. These settings will help you to fine tune the performance of VMs. We will use the following concepts:

- **Cores, Threads and Sockets.** A computer processor is connected to the motherboard through a *socket*. A processor can pack one or more *cores*, each one implements a separated processing unit that share some cache levels, memory and I/O ports. CPU Cores performance can be improved by the use of hardware *multi-threading* (SMT) that permits multiple execution flows to run simultaneously on a single core.

- **NUMA.** Multi-processor servers are usually arranged in nodes or cells. Each *NUMA node* holds a fraction of the overall system memory. In this configuration, a processor accesses memory and I/O ports local to its node faster than to the non-local ones.
• **Hugepages.** Systems with big physical memory use also a big number of virtual memory pages. This big number makes the use of virtual-to-physical translation caches inefficient. Hugepages reduces the number of virtual pages in the system and optimize the virtual memory subsystem.

In OpenNebula the virtual topology of a VM is defined by the number of sockets, cores and threads. We assume that a NUMA node or cell is equivalent to a socket and they will be used interchangeably in this guide.

### 1.6.2 Defining a Virtual Topology

#### Basic Configuration

The most basic configuration is to define just the number of vCPU (virtual CPU) and the amount of memory of the VM. In this case the guest OS will see VCPU sockets of 1 core and 1 thread each. The VM template in this case for 4 vCPUs VM is:

```
MEMORY = 1024
VCPU = 4
```

A VM running with this configuration will see the following topology:

```
# lscpu
...
CPU(s): 4
On-line CPU(s) list: 0-3
Thread(s) per core: 1
Core(s) per socket: 1
Socket(s): 4
NUMA node(s): 1
```

```
# numactl -H
available: 1 nodes (0)
node 0 cpus: 0 1 2 3
node 0 size: 1023 MB
node 0 free: 607 MB
node distances:
  0: 10
```

#### CPU Topology

You can give more detail to the previous scenario by defining a custom number of sockets, cores and threads for a given number of vCPUs. Usually, there is no significant difference between how you arrange the number of cores and sockets performance-wise. However some software products may require a specific topology setup in order to work.

For example a VM with 2 sockets and 2 cores per sockets and 2 threads per core is defined by the following template:

```
VCPU = 8
MEMORY = 1024
TOPOLOGY = [ SOCKETS = 2, CORES = 2, THREADS = 2 ]
```

and the associated guest OS view:

```
# lscpu
...
```
Important: When defining a custom CPU Topology you need to set the number of sockets, cores and threads, and it should match the total number of vCPUs, i.e. \( VCPU = SOCKETS \times CORES \times THREAD \).

### NUMA Topology

You can provide further detail to the topology of your VM by defining the placement of the sockets (NUMA nodes) into the hypervisor NUMA nodes. In this scenario each VM \( SOCKET \) will be exposed to guest OS as a separated NUMA node with its own local memory.

The previous example can expose a 2 socket (NUMA node) by setting a \( PIN\_POLICY \) (see below):

```
VCPU = 8
MEMORY = 1024
TOPOLOGY = [ PIN_POLICY = thread, SOCKETS = 2, CORES = 2, THREADS = 2 ]
```

In this case OpenNebula will generate an entry for each NUMA node, extending the previous VM template with:

```
NUMA_NODE = [ MEMORY = 512, TOTAL_CPUS = 4 ]
NUMA_NODE = [ MEMORY = 512, TOTAL_CPUS = 4 ]
```

The \textit{in-guest} OS view is for this example:

```
# lscpu
...  
CPU(s):  8  
On-line CPU(s) list: 0-7  
Thread(s) per core:  2  
Core(s) per socket:  2  
Socket(s):  2  
NUMA node(s):  2  
...  
```

```
# numactl -H
available: 2 nodes {0-1}
node 0 cpus: 0 1 2 3 4 5 6 7
node 0 size: 511 MB
node 0 free: 235 MB
node distances:
  node 0
    0: 10
```
Asymmetric topology

For some applications you may need an asymmetric NUMA configuration, i.e. not distributing the VM resources evenly across the nodes. You can define each node configuration by manually setting the `NUMA_NODE` attributes. For example:

```
MEMORY = 3072
VCPU = 6
CPU = 6
TOPOLOGY = [ PIN_POLICY = CORE, SOCKETS = 2 ]
NUMA_NODE = [ MEMORY = 1024, TOTAL_CPUS = 2 ]
NUMA_NODE = [ MEMORY = 2048, TOTAL_CPUS = 4 ]
```

**Important:** OpenNebula will also check that the total MEMORY in all the nodes matches to that set in the VM.

### 1.6.3 CPU and NUMA Pinning

When you need to expose the NUMA topology to the guest you have to set a pinning policy to map each virtual NUMA node resources (memory and vCPUs) onto the hypervisor nodes. OpenNebula can work with three different policies:

- **CORE:** each vCPU is assigned to a whole hypervisor core. No other threads in that core will be used. This policy can be useful to isolate the VM workload for security reasons.
- **THREAD:** each vCPU is assigned to a hypervisor CPU thread.
- **SHARED:** the VM is assigned a set of the hypervisor CPUS shared by all the VM vCPUs.

VM memory is assigned to the closet hypervisor NUMA node where the vCPUs are pinned, trying to prioritize local memory accesses.

When using a pinning policy it is recommended to let the scheduler pick the number of cores and threads of the virtual topology. OpenNebula will try to optimize the VM performance by selecting the threads per core according to:

- For the **CORE** pin policy the number of **THREADS** is set to 1.
- Prefer as close as possible to the hardware configuration of the host and so be power of 2.
- The threads per core will not exceed that of the hypervisor.
- Prefer the configuration with the highest number of threads/core that fits in the host.

**Important:** When **THREADS** is set OpenNebula will look for a host that can allocate that number of threads per core; if not found the VM will remain in **PENDING** state. This may be required if you want the VM to run with a fixed number of threads per core.
For example to run a 2 NUMA node VM with 8 vCPUS and 4G of memory, using the THREAD policy you can use:

<table>
<thead>
<tr>
<th>VCPU</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEMORY</td>
<td>4096</td>
</tr>
<tr>
<td>TOPOLOGY</td>
<td>[ PIN_POLICY = thread, SOCKETS = 2 ]</td>
</tr>
</tbody>
</table>

**Important:** For pinned VMs the CPU (assigned hypervisor capacity) is automatically set to the vCPU number. No overcommitment is allowed for pinned workloads.

**Pinning on LXD**

From the LXD perspective, only logical cores are perceived when assigning CPU resource to containers. The driver will only pin the cores assigned to the VM to the container, regardless of the complexity of the topology. The only required addition to pin CPUs on containers, would be TOPOLOGY = [ PIN_POLICY = <thread|core> ]

**PCI Passthrough**

The scheduling process is slightly modified when a pinned VM includes PCI passthrough devices. In this case the NUMA nodes where the PCI devices are attached to are prioritized to pin the VM vCPUs and memory to speed-up I/O operations. No additional configuration is needed.

**1.6.4 Using Hugepages**

To enable the use of hugepages for the memory allocation of the VM just add the desired page size in the TOPOLOGY attribute, the size must be expressed in megabytes. For example to use 2M hugepages use:

| TOPOLOGY | [ HUGEPAGE_SIZE = 2 ] |

OpenNebula will look for a host with enough free pages of the requested size to allocate the VM. The resources of each virtual node will be placed as close as possible to the node providing the hugepages.

**Note:** Not supported on LXD

**1.6.5 Summary of Virtual Topology Attributes**

<table>
<thead>
<tr>
<th>TOPOLOGY attribute</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIN_POLICY</td>
<td>vCPU pinning preference: CORE, THREAD, SHARED, NONE</td>
</tr>
<tr>
<td>SOCKETS</td>
<td>Number of sockets or NUMA nodes.</td>
</tr>
<tr>
<td>CORES</td>
<td>Number of cores per node</td>
</tr>
<tr>
<td>THREADS</td>
<td>Number of threads per core</td>
</tr>
<tr>
<td>HUGEPAGE_SIZE</td>
<td>Size of the hugepages (MB). If not defined no hugepages will be used</td>
</tr>
<tr>
<td>MEMORY_ACCESS</td>
<td>Control if the memory is to be mapped shared or private</td>
</tr>
</tbody>
</table>

1.6. NUMA and CPU Pinning
1.6.6 Configuring the Host

When running VMs with a specific topology it is important to map (pin) it as close as possible to the that on the hypervisor, so vCPUs and memory are allocated into the same NUMA node. However, by default a VM is assigned to all the resources in the system making incompatible running pinned and no-pinned workloads in the same host.

First you need to define which hosts are going to be used to run pinned workloads, and define the PIN_POLICY tag through Sunstone or using `onehost update` command. A Host can operate in two modes:

- **NONE.** Default mode where no NUMA or hardware characteristics are considered. Resources are assigned and balanced by an external component, e.g. numad or kernel.
- **PINNED.** VMs are allocated and pinned to specific nodes according to different policies.

**Note:** You can also create an OpenNebula Cluster including all the Host devoted to run pinned workloads, and set the PIN_POLICY at the cluster level.

The host monitoring probes should also return the NUMA topology and usage status of the hypervisors. The following command shows a single node hypervisor with 4 cores and 2 threads running a 2 vCPU VM:

```
$ onehost show 0
...
MONITORING INFORMATION
PIN_POLICY="PINNED"
...
NUMA NODES

<table>
<thead>
<tr>
<th>ID</th>
<th>CORES</th>
<th>USED</th>
<th>FREE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>X-</td>
<td>-</td>
<td>4</td>
</tr>
</tbody>
</table>

NUMA MEMORY

<table>
<thead>
<tr>
<th>NODE_ID</th>
<th>TOTAL</th>
<th>USED_REAL</th>
<th>USED_ALLOCATED</th>
<th>FREE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7.6G</td>
<td>6.8G</td>
<td>1024M</td>
<td>845.1M</td>
</tr>
</tbody>
</table>

In this output, the string `X- X- -- --` represents the NUMA allocation: each group is a core, when a thread is free is shown as `-`, `x` means the thread is in use and `X` means that the thread is used and the core has no free threads. In this case the VM is using the CORE pin policy.

**Note:** If you want to use hugepages of a given size you need to allocate them first. This can be done either at boot time or dynamically. Also you may need need to mount the `hugetlbfs` filesystem. Please refer to your OS documentation to learn how to do this.

You can also isolate some hypervisor CPUs from the NUMA scheduler. Isolated CPUs will not be used to pin any VM. The isolated CPUs are defined with the ISOLCPUS attribute, the attribute is a comma separated list of CPU IDs. For example `ISOLCPUS="0,5"` will isolated CPUs 0,5 and hence will not be used to pin any VM.

**CPU Pinning and Overcommitment**

When using a pinned policy, overcommitment is disabled by default (CPU = 1 in the VM template). However, some scenarios may require to fix the CPU thread where a VM is running while letting more VMs run in the very same CPU thread.
You can configure the number of VMS per physical thread for each host by setting the `VMS_THREAD` (defaults to 1) variable in the host template. For example `VMS_THREAD = 4` will pin up to 4 VMS per physical thread in each core.

**Important:** When using overcommitment and NUMA you need to set the host overcommitment in the same way, so the total CPU number accounts for the new `VMS_THREAD` value. For example, a host with 8 CPUs (`TOTAL_CPU=800`) and `VMS_THREAD=4` need to overcommit the CPU number so the `TOTAL_CPU` at most 3200 (8 * 4 = 32 CPUs, max.). You can do this with the `RESERVED_CPU` attribute for the host, `RESERVED_CPU = "-2400"` in this case (3200 = 800 - (-2400)).

### 1.6.7 A Complete Example

Let us define a VM with two NUMA nodes using 2M hugepages, 4 vCPUs and 1G of memory. The template is as follows:

```plaintext
MEMORY = "1024"
CPU = "4"
VCPU = "4"
CPU_MODEL = [ MODEL="host-passthrough"]

TOPOLOGY = [  
  HUGEPAGE_SIZE = "2",  
  MEMORY_ACCESS = "shared",  
  NUMA_NODES = "2",  
  PIN_POLICY = "THREAD"]

DISK = [ IMAGE="CentOS7"]
NIC = [ IP="10.4.4.11", NETWORK="Management"]

CONTEXT = [ NETWORK="YES", SSH_PUBLIC_KEY="$USER[$SSH_PUBLIC_KEY]" ]
```

The VM is deployed in a hypervisor with the following characteristics, 1 node, 8 CPUs and 4 cores:

```plaintext
# numactl -H
available: 1 nodes (0)
node 0 cpus: 0 1 2 3 4 5 6 7
node 0 size: 7805 MB
node 0 free: 2975 MB
node distances:
  node 0
    0: 10
```

and 8G of memory with a total of 2048 2M hugepages:

```plaintext
# numastat -m
                      Node 0      Total
              -----------------    -----------------
MemTotal          7805.56    7805.56
MemFree           862.80     862.80
MemUsed           6942.76    6942.76
...  
HugePages_Total   2048.00    2048.00
HugePages_Free    1536.00    1536.00
HugePages_Surp    0.00       0.00
```

### 1.6. NUMA and CPU Pinning
This characteristics can be also queried through the OpenNebula CLI:

```bash
$ onehost show 0
...

NUMA NODES

<table>
<thead>
<tr>
<th>ID</th>
<th>CORES</th>
<th>USED</th>
<th>FREE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>XX</td>
<td>XX</td>
<td>4</td>
</tr>
</tbody>
</table>

NUMA MEMORY

<table>
<thead>
<tr>
<th>NODE_ID</th>
<th>TOTAL</th>
<th>USED_REAL</th>
<th>USED_ALLOCATED</th>
<th>FREE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7.6G</td>
<td>6.8G</td>
<td>1024M</td>
<td>845.1M</td>
</tr>
</tbody>
</table>

NUMA HUGEPAGES

<table>
<thead>
<tr>
<th>NODE_ID</th>
<th>SIZE</th>
<th>TOTAL</th>
<th>FREE</th>
<th>USED</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2M</td>
<td>2048</td>
<td>1536</td>
<td>512</td>
</tr>
<tr>
<td></td>
<td>1024M</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note that in this case the previous VM has been pinned to 4 CPUs (0,4,1,5) and it is using 512 pages of 2M. You can verified that the VM is actually running in this resources through libvirt:

```
virsh # vcpuinfo 1
VCPU: 0
CPU: 0
State: running
CPU time: 13.0s
CPU Affinity: y-------
VCPU: 1
CPU: 4
State: running
CPU time: 5.8s
CPU Affinity: ----y---
VCPU: 2
CPU: 1
State: running
CPU time: 39.1s
CPU Affinity: -y------
VCPU: 3
CPU: 5
State: running
CPU time: 25.4s
CPU Affinity: -----y--
```

You can also check the Guest OS point of view by executing the previous commands in the VM. It should show 2 nodes with 2 CPUs (threads) per core and 512M each:

```
# numactl -H
available: 2 nodes (0-1)
node 0 cpus: 0 1
node 0 size: 511 MB
node 0 free: 401 MB
```

1.6. NUMA and CPU Pinning
### 1.6. NUMA and CPU Pinning

#### 1.6.8 Considerations and Limitations

Please consider the following limitations when using pinned VMs:

- **VM Migration.** Pinned VMs cannot VM live migrated, you need to migrate the VMs through a power off - power on cycle.
- **Re-sizing of asymmetric virtual topologies is not supported, as the NUMA nodes are re-generated with the new VCPU and MEMORY values. Also note that the pinned CPUs may change.**
- **Asymmetric configurations.** As for qemu 4.0 and libvirt 5.4 NUMA nodes cannot be defined with no memory or without any CPU, you’ll get the following errors:
2.1 Overview

OpenNebula includes a complete user & group management system. Users in an OpenNebula installation are classified in four types:

- **Administrators**, an admin user belongs to an admin group (oneadmin or otherwise) and can perform manage operations.
- **Regular users**, that may access most OpenNebula functionality.
- **Public users**, only basic functionality (and public interfaces) are open to public users.
- **Service users**, a service user account is used by the OpenNebula services (i.e. cloud APIs like EC2 or GUI’s like Sunstone) to proxy auth requests.

The resources a user may access in OpenNebula are controlled by a permissions system that resembles the typical UNIX one. By default, only the owner of a resource (e.g. a VM or an image) can use and manage it. Users can easily share the resources by granting use or manage permissions to other users in her group or to any other user in the system.

Upon group creation, an associated admin user can be created. By default this user will be able to create users in the new group, and manage non owned resources for the regular group, through the CLI and/or a special Sunstone view. This group can also be assigned to VDC, what is basically a pool of OpenNebula physical resources (hosts, datastores and virtual networks).

Along with the users & groups the Auth Subsystem is responsible for the authentication and authorization of user’s requests.

Any interface to OpenNebula (CLI, Sunstone, Ruby or Java OCA) communicates with the core using XML-RPC calls, that contain the user’s session string, which is authenticated by the OpenNebula core comparing the username and password with the registered users.

Each operation generates an authorization request that is checked against the registered ACL rules. The core then can grant permission, or reject the request.

OpenNebula comes with a default set of ACL rules that enables a standard usage. You don’t need to manage the ACL rules unless you need the level of permission customization if offers.

By default, the authentication and authorization is handled by the OpenNebula Core as described above. Optionally, you can delegate it to an external module, see the Authentication Guide for more information.

2.1.1 How Should I Read This Chapter

From these guides you should read at least the ones for Users, Groups and Permissions as are the basis for any cloud:
2.1.2 Hypervisor Compatibility

These guides are compatible with all hypervisors.

2.2 Managing Users

OpenNebula supports user accounts and groups. This guide shows how to manage users, groups are explained in their own guide. To manage user rights, visit the Managing ACL Rules guide.

A user in OpenNebula is defined by a username and password. You don’t need to create a new Unix account in the front-end for each OpenNebula user, they are completely different concepts. OpenNebula users are authenticated using a session string included in every operation, which is checked by the OpenNebula core.

Each user has a unique ID, and belongs to a group.

After the installation, you will have two administrative accounts, oneadmin and serveradmin; and two default groups. You can check it using the oneuser list and onegroup list commands.

There are different user types in the OpenNebula system:

- **Cloud Administrators**, the oneadmin account is created the first time OpenNebula is started using the ONE_AUTH data. oneadmin has enough privileges to perform any operation on any object. Any other user in the oneadmin group has the same privileges as oneadmin

- **Infrastructure User** accounts may access most of the functionality offered by OpenNebula to manage resources.

- **Group Administrators** accounts manage a limited set of resources and users.

- **Users** access a simplified Sunstone view with limited actions to create new VMs, and perform basic life cycle operations.

- User serveradmin is also created the first time OpenNebula is started. Its password is created randomly, and this account is used by the Sunstone server to interact with OpenNebula.

**Note:** The complete OpenNebula approach to user accounts, groups and VDC is explained in more detail in the Understanding OpenNebula guide.
2.2.1 Characters limitations

When defining user names and passwords consider the following invalid characters

```plaintext
username = [" ", ":", ":\t", ":\n", ":\v", ":\f", ":\r"]
password = [" ", ":\t", ":\n", ":\v", ":\f", ":\r"]
```

Shell Environment

OpenNebula users should have the following environment variables set, you may want to place them in the .bashrc of the user’s Unix account for convenience:

**ONE_XMLRPC**

URL where the OpenNebula daemon is listening. If it is not set, CLI tools will use the default: http://localhost:2633/RPC2. See the PORT attribute in the Daemon configuration file for more information.

**ONE_XMLRPC_TIMEOUT**

Number of seconds to wait before a xmlrpc request timeouts.

**ONE_AUTH**

Needs to point to a file containing a valid authentication key, it can be:

- A password file with just a single line stating username:password.
- A token file with just a single line with username:token, where token is a valid token created with the oneuser login command or API call.

If **ONE_AUTH** is not defined, $HOME/.one/one_auth will be used instead. If no auth file is present, OpenNebula cannot work properly, as this is needed by the core, the CLI, and the cloud components as well.

**ONE_POOL_PAGE_SIZE**

By default the OpenNebula Cloud API (CLI and Sunstone make use of it) paginates some pool responses. By default this size is 300 but it can be changed with this variable. A numeric value greater that 2 is the pool size. To disable it you can use a non numeric value.

```
$ export ONE_POOL_PAGE_SIZE=5000  # Sets the page size to 5000
$ export ONE_POOL_PAGE_SIZE=disabled  # Disables pool pagination
```

**ONE_PAGER**

List commands will send their output through a pager process when in an interactive shell. By default, the pager process is set to less but it can be change to any other program.

The pagination can be disabled using the argument --no-pager. It sets the ONE_PAGER variable to cat.

**ONE_LISTCONF**

Allows the user to use an alternate layout to displays lists. The layouts are defined in /etc/one/cli/onevm.yaml.

```
$ onevm list
ID   USER       GROUP     NAME     STAT  UCPU  UMEM     HOST                TIME
20   oneadmin   oneadmin  tty-20   fail  0      0K localhost 0d 00h32
21   oneadmin   oneadmin  tty-21   fail  0      0K localhost 0d 00h23
22   oneadmin   oneadmin  tty-22   runn 0.0    104.7M localhost 0d 00h22

$ export ONE_LISTCONF=user
$ onevm list
```

2.2. Managing Users
OpenNebula 5.10 Operation Guide, Release 5.10.3

<table>
<thead>
<tr>
<th>ID</th>
<th>NAME</th>
<th>IP</th>
<th>STAT</th>
<th>UCPU</th>
<th>UMEM</th>
<th>HOST</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>tty-20</td>
<td>10.3.4.20</td>
<td>fail</td>
<td>0</td>
<td>0K</td>
<td>localhost</td>
<td>0d 00h32</td>
</tr>
<tr>
<td>21</td>
<td>tty-21</td>
<td>10.3.4.21</td>
<td>fail</td>
<td>0</td>
<td>0K</td>
<td>localhost</td>
<td>0d 00h23</td>
</tr>
<tr>
<td>22</td>
<td>tty-22</td>
<td>10.3.4.22</td>
<td>runn</td>
<td>0.0</td>
<td>104.7M</td>
<td>localhost</td>
<td>0d 00h23</td>
</tr>
</tbody>
</table>

**ONE_CERT_DIR** and **ONE_DISABLE_SSL_VERIFY**

If OpenNebula XML-RPC endpoint is behind an SSL proxy you can specify an extra trusted certificates directory using **ONE_CERT_DIR**. Make sure that the certificate is named `<hash>.0`. You can get the hash of a certificate with this command:

```
$ openssl x509 -in <certificate.pem> -hash
```

Alternatively you can set the environment variable **ONE_DISABLE_SSL_VERIFY** to any value to disable certificate validation. You should only use this parameter for testing as it makes the connection insecure.

For instance, a user named regularuser may have the following environment:

```
$ tail ~/.bashrc
ONE_XMLRPC=http://localhost:2633/RPC2
export ONE_XMLRPC
$ cat ~/.one/one_auth
regularuser:password
```

**Note:** Please note that the example above is intended for a user interacting with OpenNebula from the front-end, but you can use it from any other computer. Just set the appropriate hostname and port in the **ONE_XMLRPC** variable.

**Note:** If you do not want passwords to be stored in plain files, protected with basic filesystem permissions, please refer to the token-based authentication mechanism described below.

An alternative method to specify credentials and OpenNebula endpoint is using command line parameters. Most of the commands can understand the following parameters:

```
--user name       User name used to connect to OpenNebula
--password password Password to authenticate with OpenNebula
--endpoint endpoint URL of OpenNebula XML-RPC Front-end
```

If `user` is specified but not `password` the user will be prompted for the password. `endpoint` has the same meaning and get the same value as **ONE_XMLRPC**. For example:

```
$ onevm list --user my_user --endpoint http://one.frontend.com:2633/RPC2
Password: [\...]
```

**Warning:** You should better not use **--password** parameter in a shared machine. Process parameters can be seen by any user with the command `ps` so it is highly insecure.

**ONE_SUNSTONE**

2.2. Managing Users
URL of the Sunstone portal, used for downloading MarketPlaceApps streamed through Sunstone. If this is not specified, it will be inferred from ONE/XMLRPC (by changing the port to 9869), and if that env variable is undefined as well, it will default to http://localhost:9869.

**ONEFLOW_URL, ONEFLOW_USER and ONEFLOW_PASSWORD**

These variables are used by the OneFlow command line tools. If not set, the default OneFlow URL will be http://localhost:2474. The user and password will be taken from the ONE_AUTH file if the environment variables are not found.

### 2.2.2 Shell Environment for Self-Contained Installations

If OpenNebula was installed from sources in self-contained mode (this is not the default, and not recommended), these two variables must be also set. These are not needed if you installed from packages, or performed a system-wide installation from sources.

**ONE_LOCATION**

It must point to the installation `<destination_folder>`.

**PATH**

The OpenNebula bin files must be added to the path

```bash
$ export PATH=$ONE_LOCATION/bin:$PATH
```

### Adding and Deleting Users

User accounts within the OpenNebula system are managed by `oneadmin` with the `oneuser create` and `oneuser delete` commands. This section will show you how to create the different account types supported in OpenNebula

#### 2.2.3 Administrators

Administrators can be easily added to the system like this:

```bash
$ oneuser create otheradmin password
ID: 2

$ oneuser chgrp otheradmin oneadmin

$ oneuser list

<table>
<thead>
<tr>
<th>ID</th>
<th>GROUP</th>
<th>NAME</th>
<th>AUTH</th>
<th>PASSWORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>oneadmin</td>
<td>oneadmin</td>
<td>core</td>
<td>5baa61e4c9b93f3f0682250b6cf8331b7ee68fd8</td>
</tr>
<tr>
<td>1</td>
<td>oneadmin</td>
<td>serveradmin</td>
<td>server_c</td>
<td>1224ff12545a2e5dfeda4eddacdc682d719c26d5</td>
</tr>
<tr>
<td>2</td>
<td>oneadmin</td>
<td>otheradmin</td>
<td>core</td>
<td>5baa61e4c9b93f3f0682250b6cf8331b7ee68fd8</td>
</tr>
</tbody>
</table>

$ oneuser show otheradmin

**USER 2 INFORMATION**

<table>
<thead>
<tr>
<th>ID</th>
<th>NAME</th>
<th>PASSWORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>otheradmin</td>
<td>5baa61e4c9b93f3f0682250b6cf8331b7ee68fd8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GROUP</th>
<th>AUTH_DRIVER</th>
<th>ENABLED</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>core</td>
<td>Yes</td>
</tr>
</tbody>
</table>
```
2.2.4 Regular Users

Simply create the users with the create command:

```bash
$ oneuser create regularuser password
ID: 3
```

The enabled flag can be ignored as it doesn’t provide any functionality. It may be used in future releases to temporarily disable users instead of deleting them.

2.2.5 Public Users

Public users need to define a special authentication method that internally relies on the core auth method. First create the public user as it was a regular one:

```bash
$ oneuser create publicuser password
ID: 4
```

and then change its auth method (see below for more info) to the public authentication method.

```bash
$ oneuser chauth publicuser public
```

2.2.6 Server Users

Server user accounts are used mainly as proxy authentication accounts for OpenNebula services. Any account that uses the `server_cipher` or `server_x509` auth methods are a server user. You will never use this account directly. To create a server user account just create a regular account

```bash
$ oneuser create serveruser password
ID: 5
```

and then change its auth method to `server_cipher` (for other auth methods please refer to the Authentication guide):

```bash
$ oneuser chauth serveruser server_cipher
```

Managing Users

2.2.7 User Authentication

In order to authenticate with OpenNebula you need a valid password or authentication token. Its meaning depends on the authentication driver, `AUTH_DRIVER`, set for the user. Note that you will be using this password or token to authenticate within the Sunstone portal or at the CLI/API level.

The default driver, `core`, is a simple user-password match mechanism. To configure a user account simply add to `$HOME/.one/one_auth` a single line with the format `<username>:<password>`. For example, for user `oneadmin` and password `opennebula` the file would be:
Once configured you will be able to access the OpenNebula API and use the CLI tools:

```bash
$ oneuser show
USER 0 INFORMATION
ID : 0
NAME : oneadmin
GROUP : oneadmin
PASSWORD : c24783ba96a35464632a624d9f829136edc0175e
```

**Note:** OpenNebula does not store the plain password but a hashed version in the database, as show by the oneuser example above.

### 2.2.8 Tokens

$HOME/.one/one_auth is just protected with the standard filesystem permissions. To improve the system security you can use authentication tokens. In this way there is no need to store plain passwords, OpenNebula can generate or use an authentication token with a given expiration time. By default, the tokens are also stored in $HOME/.one/one_auth.

Furthermore, if the user belongs to multiple groups, a token can be associated to one of those groups, and when the user operates with that token he will be effectively in that group, i.e. he will only see the resources that belong to that group, and when creating a resource it will be placed in that group.

**Create a token**

Any user can create a token:

```bash
$ oneuser token-create
File /var/lib/one/.one/one_auth exists, use --force to overwrite.
Authentication Token is:
testuser:b61010c8ef7a1e815ec2836ea7691e92c4d3f316
```

The expiration time of the token is by default 10h (36000 seconds). When requesting a token the option `--time <seconds>` can be used in order to define exactly when the token will expire. A value of -1 disables the expiration time.

The token can be created associated with one of the group the user belongs to. If the user logs in with that token, he will be effectively **only** in that group, and will only be allowed to see the resources that belong to that group, as opposed to the default token, which allows access to all the resources available to the groups that the user belongs to. In order to specify a group, the option `--group <id|group>` can be used. When a group specific token is used, any newly created resource will be placed in that group.

**List the tokens**

Tokens can be listed by doing:

```bash
$ oneuser show
[...]
TOKENS
    ID  EGID  EGROUP  EXPIRATION
3ea673b 100  groupB  2016-09-03 03:58:51
```
The asterisk in the EGID column means that the user’s primary group is 1 and that the token is not group specific.

Set (enable) a token

A token can be enabled by doing:

```bash
$ oneuser token-set --token b6
export ONE_AUTH=/var/lib/one/.one/5ad20d96-964a-4e09-b550-9c29855e6457.token; export ONE_EGID=-1
$ export ONE_AUTH=/var/lib/one/.one/5ad20d96-964a-4e09-b550-9c29855e6457.token; export ONE_EGID=-1
```

Delete a token

A token can be removed similarly, by doing:

```bash
$ oneuser token-delete b6
Token removed.
```

Convenience bash functions

The file `/usr/share/one/onetoken.sh` contains two convenience functions: `onetokencreate` and `onetokenset`.

Usage example:

```bash
$ source /usr/share/one/onetoken.sh
$ onetokencreate
Password:
File /var/lib/one/.one_auth exists, use --force to overwrite.
Authentication Token is:
testuser:f65c77250cfd375dd83873ad68598edc6593a39e
Token loaded.
$ cat $ONE_AUTH
testuser:f65c77250cfd375dd83873ad68598edc6593a39e%
$ oneuser show
[...]
<table>
<thead>
<tr>
<th>TOKENS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
</tr>
<tr>
<td>3e5673b</td>
</tr>
<tr>
<td>c33ff10</td>
</tr>
<tr>
<td>f65c772</td>
</tr>
</tbody>
</table>
[...]
$ onetokenset 3e
Token loaded.
$ cat $ONE_AUTH
testuser:3e673b90d318e4f5e67a83c220f57cd33618421
```

Note the `onetokencreate` supports the same options as `oneuser token-create`, like `--time` and `--group`.

2.2. Managing Users
2.2.9 User Templates

The USER TEMPLATE section can hold any arbitrary data. You can use the oneuser update command to open an editor and add, for instance, the following DEPARTMENT and EMAIL attributes:

```
$ oneuser show 2
USER 2 INFORMATION
ID : 2
NAME : regularuser
GROUP : 1
PASSWORD : 5baa61e4c9b93f3f0682250b6cf8331b7ee68fd8
AUTH_DRIVER : core
ENABLED : Yes

USER TEMPLATE
DEPARTMENT=IT
EMAIL=user@company.com
```

These attributes can be later used in the Virtual Machine Contextualization. For example, using contextualization the user's public ssh key can be automatically installed in the VM:

```
ssh_key = "$USER[SSH_KEY]"
```

The User template can be used to customize the access rights for the VM_USE_OPERATIONS, VM_MANAGE_OPERATIONS and VM_ADMIN_OPERATIONS. For a description of these attributes see VM Operations Permissions.

Manage your Own User

Regular users can see their account information, and change their password.

For instance, as regularuser you could do the following:

```
$ oneuser list

$ oneuser show
USER 2 INFORMATION
ID : 2
NAME : regularuser
GROUP : 1
PASSWORD : 5baa61e4c9b93f3f0682250b6cf8331b7ee68fd8
AUTH_DRIVER : core
ENABLED : Yes

USER TEMPLATE
DEPARTMENT=IT
EMAIL=user@company.com

$ oneuser passwd 1 abcdpass
```

As you can see, any user can find out his ID using the oneuser show command without any arguments.

Regular users can retrieve their quota and user information in the settings section in the top right corner of the main
Finally some configuration attributes can be set to tune the behavior of Sunstone or OpenNebula for the user. For a description of these attributes please check the group configuration guide.

Managing Users in Sunstone

All the described functionality is available graphically using Sunstone:
Change credentials for oneadmin or serveradmin

In order to change the credentials of oneadmin you have to do the following:

Note:

```bash
# oneuser passwd 0 <PASSWORD>
# echo 'oneadmin:PASSWORD' > /var/lib/one/.one/one_auth
```

After changing the password, please restart OpenNebula (make sure the mm_sched process is also restarted)

In order to change the credentials of serveradmin you have to do the follow these steps.

2.3 Managing Groups

A group in OpenNebula makes it possible to isolate users and resources. A user can see and use the shared resources from other users.

The group is an authorization boundary for the users, but you can also partition your cloud infrastructure and define what resources are available to each group using Virtual Data Centers (VDC). You can read more about OpenNebula’s approach to VDCs and the cloud from the perspective of different user roles in the Understanding OpenNebula guide.

2.3.1 Adding and Deleting Groups

There are two special groups created by default. The oneadmin group allows any user in it to perform any operation, allowing different users to act with the same privileges as the oneadmin user. The users group is the default group where new users are created.

Your can use the onegroup command line tool to manage groups in OpenNebula. There are two groups created by default, oneadmin and users.

To create new groups:

```bash
$ onegroup list
  ID  NAME
  0  oneadmin
  1  users

$ onegroup create "new group"
  ID: 100
```

The new group has ID 100 to differentiate the special groups from the user-defined ones.

Note: When a new group is created, an ACL rule is also created to provide the default behavior, allowing users to create basic resources. You can learn more about ACL rules in this guide; but you don’t need any further configuration to start using the new group.

2.3.2 Adding Users to Groups

Use the oneuser chgrp command to assign users to groups.
To delete a user from a group, just move it again to the default users group.

### 2.3.3 Admin Users and Allowed Resources

Upon group creation, a special admin user account can be defined. This admin user will have administrative privileges only for the new group, not for all the resources in the OpenNebula cloud as the ‘oneadmin’ group users have.

Another aspect that can be controlled on creation time is the type of resources that group users will be allowed to create.

This can be managed visually in Sunstone, and can also be managed through the CLI. In the latter, details of the group are passed to the onegroup create command as arguments. This table lists the description of said arguments.

<table>
<thead>
<tr>
<th>Argument</th>
<th>M / O</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-n, –name name</td>
<td>Manda-</td>
<td>Any string</td>
<td>Name for the new group</td>
</tr>
<tr>
<td>-u, –admin_user</td>
<td>Op-</td>
<td>Any string</td>
<td>Creates an admin user for the group with the given name</td>
</tr>
<tr>
<td>-p, –admin_password</td>
<td>Op-</td>
<td>Any string</td>
<td>Password for the admin user of the group</td>
</tr>
<tr>
<td>-d, –admin_driver</td>
<td>Op-</td>
<td>Any string</td>
<td>Auth driver for the admin user of the group</td>
</tr>
<tr>
<td>-r, –resources</td>
<td>Op-</td>
<td>“+” separated list</td>
<td>Which resources can be created by group users (VM+IMAGE+TEMPLATE by default)</td>
</tr>
</tbody>
</table>

An example:

```bash
$ onegroup create --name groupA \
    --admin_user admin_userA --admin_password somestr \ 
    --resources TEMPLATE+VM
```
2.3.4 Add Admin Users to an Existing Group

Any user can be configured to be Admin of a group with the commands `onegroup addadmin` and `deladmin`. 
2.3.5 Managing Groups and Virtual Resources

You can make the following virtual resources available to group users:

- Virtual Machine Templates
- Service Templates
- Images
- Files & Kernels

To make a virtual resource owned by oneadmin available to users of the new group, you have two options:

- Change the resource’s group, and give it GROUP USE permissions. This will make the resource only available to users in that group. The recommended practice to assign golden resources to groups is to first clone the resource and then assign it to the desired group for their users’ consumption.

- Leave the resource in the oneadmin group, and give it OTHER USE permissions. This will make the resource available to every user in OpenNebula.

The Virtual Machine and Service Templates are visible to the group users when they want to create a new VM or Service. The Images (including File Images) used by those Templates are not visible to the users, but must be also made available, otherwise the VM creation will fail with an error message similar to this one:

```
```

You can read more about OpenNebula permissions in the Managing Permissions and Managing ACL Rules guides.
2.3.6 Resource Sharing

When a new group is created the cloud administrator can define if the users of this view will be allowed to view the VMs and Services of other users in the same group. If this option is checked a new ACL rule will be created to give users in this group access to the VMS and Services in the same group. Users will not able to manage these resources but they will be included in the list views of each resource.

Create Group

2.3.7 Primary and Secondary Groups

With the commands `oneuser addgroup` and `delgroup` the administrator can add or delete secondary groups. Users assigned to more than one group will see the resources from all their groups. e.g. a user in the groups testing and production will see VMs from both groups.

The group set with `chgrp` is the primary group, and resources (Images, VMs, etc) created by a user will belong to this primary group. Users can change their primary group to any of their secondary group without the intervention of an administrator, using `chgrp` again.

2.3.8 Group-wise Configuration Attributes

When a group is created you can define specific configuration aspects for the group users. These include:

- Sunstone. Allow users and group admins to access specific views. The configuration attributes are stored in the group template in the `SUNSTONE` attribute:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEFAULT_VIEW</td>
<td>Default Sunstone view for regular users</td>
</tr>
<tr>
<td>VIEWS</td>
<td>List of available views for regular users</td>
</tr>
<tr>
<td>GROUP_ADMIN_DEFAULT_VIEW</td>
<td>Default Sunstone view for group admin users</td>
</tr>
<tr>
<td>GROUP_ADMIN_VIEWS</td>
<td>List of available views for the group admins</td>
</tr>
</tbody>
</table>
The views are defined by a comma separated list of group names. By default the following views are defined: **groupadmin, cloud, admin, user, admin_vcenter, cloud_vcenter, groupadmin_vcenter**

Example:

```json
SUNSTONE = {
    DEFAULT_VIEW = "cloud",
    VIEWS = "cloud",
    GROUP_ADMIN_DEFAULT_VIEW = "groupadmin",
    GROUP_ADMIN_VIEWS = "groupadmin,cloud"
}
```

- OpenNebula Core. Set specific attributes to control some operations. The configuration attributes are stored in the group template in the **OPENNEBULA attribute**:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEFAULT_IMAGE_PERSISTENT</td>
<td>Control the default value for the PERSISTENT attribute on image creation (clone and disk save-as).</td>
</tr>
<tr>
<td>DEFAULT_IMAGE_PERSISTENT_NEW</td>
<td>Control the default value for the PERSISTENT attribute on image creation (only new images).</td>
</tr>
<tr>
<td>API_LIST_ORDER</td>
<td>Sets order (by ID) of elements in list API calls (e.g. onevm list). Values: ASC (ascending order) or DESC (descending order)</td>
</tr>
</tbody>
</table>

The Group template can be used to customize the access level of the **VM_USE_OPERATIONS**, **VM_MANAGE_OPERATIONS** and **VM_ADMIN_OPERATIONS**. For a description of these attributes see VM Operations Permissions.

**Note:** These values can be overwritten for each user by placing the desired values in the user template.

If the values are not set the defaults defined in **oned.conf** are used.

Example:

```json
OPENNEBULA = {
    DEFAULT_IMAGE_PERSISTENT = "YES",
    DEFAULT_IMAGE_PERSISTENT_NEW = "NO"
}
```

### 2.3.9 Managing Groups in Sunstone

All the described functionality is available graphically using Sunstone:
There is an option to filter all system resources by group. In the user’s menu appear the groups of this user. There’s the option All to see all system resources. When you filter by group, you also change the effective group of the user. This allows to work more comfortably on projects, by isolating the resources belonging to one group from others.

It’s possible to show the filter in the top menu.

```
filter-view: true
```
2.4 Managing VDCs

A VDC (Virtual Data Center) defines an assignment of one or several groups to a pool of physical resources. This pool of Physical Resources consists of resources from one or several Clusters that could belong to different Zones or public external clouds for hybrid cloud computing. You can read more about OpenNebula’s approach to VDCs and the cloud from the perspective of different user roles in the Understanding OpenNebula guide.

2.4.1 The Default VDC

There is a special default VDC created during the installation that allows the use of ALL the physical resources. The users group belongs to this VDC, and any new group is automatically added to the default VDC. You can modify the VDC physical resources, even remove all of them, but it can’t be deleted.

Note: Before adding a new group to a specific VDC, you may want to remove it from the default one, since it allows the use of ALL the physical resources.

2.4.2 Adding and Deleting VDCs

You can use the onevdc command line tool to manage VDCs in OpenNebula.

To create new VDCs:

```bash
$ onevdc list
ID  NAME
  0  default

$ onevdc create "high-performance"
ID: 100
```

The new VDC has ID 100 to differentiate the default VDC from the user-defined ones.

2.4.3 Adding Groups to VDCs

By default a group doesn’t belong to any VDC, so users won’t be entitled to use any resource until explicitly added to one.

To add groups to a VDC:

```bash
$ onevdc addgroup <vdc_id> <group_id>
```

2.4.4 Adding Physical Resources to VDCs

Physical resources (hosts, virtual networks, and datastores) can be added to the VDC. Internally, the VDC will create ACL Rules that will allow the VDC groups to use this pool of resources.

Typically, you will want to add Clusters to the VDC. For instance, Cluster 7 from Zone 0:

```bash
$ onevdc addcluster <vdc_id> 0 7
```

But you can also add individual hosts, virtual networks, and datastores:
The special id ALL can be used to add all clusters(hosts/vnets/datastores) from the given zone:

```
$ onevdc addcluser <group_id> 0 ALL
```

To remove physical resources from the VDC, use the symmetric operations `delcluster`, `delhost`, `delvnet`, `deldatastore`.

When you assign physical resources to a VDC, users in that VDC’s groups will be able to use the Datastores and Virtual Networks. The scheduler will also deploy VMs from that group to any of the VDC Hosts.

If you are familiar with ACL rules, you can take a look at the rules that are created with `oneacl list`. These rules are automatically added, and should not be manually edited. They will be removed by the `onevdc del*` commands. The default permissions for these rules can be configured into oned.conf

### 2.4.5 Examples

The VDC management offers plenty of flexibility to suit many different scenarios. This section lists a few of them to help to visualize the possibilities of your OpenNebula infrastructure.

For example, let’s say Web Development, Human Resources, and Big Data Analysis as business units represented by Groups in a private OpenNebula cloud, with resources allocated from your zones and public clouds in order to create three different VDCs.

- **VDC BLUE**: VDC that allocates resources from DC_West_Coast + Cloudbursting to Web Development
- **VDC RED**: VDC that allocates resources from DC_West_Coast + DC_Europe + Cloudbursting to Human Resources
- **VDC GREEN**: VDC that allocates resources from DC_West_Coast + DC_Europe to Big Data Analysis
Flexible Groups

If you plan to have a small infrastructure, the VDC management may seem like an unnecessary extra step to assign physical resources to each Group. But having an independent VDC object allows it to have more than one Group, and at the same time a Group can be part of more than one VDC.

In practical terms, this means that once you organize your Users into Groups, and then your physical resources into VDCs, you can easily assign more or less resources to those Groups.

Using the previous scenario as an example, the Cloud Admin can add the Group Web Development to the VDCs RED and GREEN if their workload increases, and then remove it again a few days later.

Create Super-Clusters

A VDC can have more than one physical resource of each type (Cluster, Hosts, VNets, Datastores), and a physical resource can be in more than one VDC. In contrast a Host can be part of only one Cluster. This means that you can decide to create a VDC that encompasses resources that may not be part of the same physical Cluster.

For example, a VDC called ‘high-performance’ may contain Hosts from two incompatible Clusters, let’s say ‘kvm-ceph’ and ‘kvm-qcow2’. These Hosts may be part of the same VDC, but from the deployment point of view, the important factor is their Cluster. The scheduler will decide the deployment target based on each Host’s Cluster, and this guarantees that the VMs are always deployed in a compatible Host.

Partition a Cluster

Since a VDC can contain individual Hosts, VNets and Datastores, you can use VDCs to partition a Cluster into “sub-clusters” that contain a few Hosts.
Following the previous example, you may have a big “kvm-ceph” Cluster. A VDC with one or two Hosts can be created to isolate a small portion of the Cluster. In this case, remember to add the necessary Datastores and VNets to the VDC, otherwise the Users won’t be able to instantiate the VM Templates.

**Share Physical Resources**

You may have two Groups with a similar workload, but want to keep their users and virtual resources isolated. In this case, both can be added to the same VDC. In a similar way, a physical resource (such as a host) can be part of two different VDCs.

The Groups will share the physical resources, but without being aware of it. If the physical resources are not exclusively assigned to a Group, you may want to set *usage quotas*.

### 2.4.6 Managing VDCs in Sunstone

All the described functionality is available graphically using Sunstone:

![Create Virtual Data Center in Sunstone](image)

### 2.5 Managing Permissions

Most OpenNebula resources have associated permissions for the **owner**, the users in her **group**, and **others**. For each one of these groups, there are three rights that can be set: **USE**, **MANAGE** and **ADMIN**. These permissions are very similar to those of UNIX file system.

The resources with associated permissions are **Templates**, **VMs**, **Images** and **Virtual Networks**. The exceptions are **Users**, **Groups** and **Hosts**.
2.5.1 Managing Permission through the CLI

This is how the permissions look in the terminal:

```bash
$ onetemplate show 0
TEMPLATE 0 INFORMATION
ID : 0
NAME : vm-example
USER : oneuser1
GROUP : users
REGISTER TIME : 01/13 05:40:28

PERMISSIONS
OWNER : um-
GROUP : u--
OTHER : ---

[...]
```

The previous output shows that for the Template 0, the owner user `oneuser1` has `USE` and `MANAGE` rights. Users in the group `users` have `USE` rights, and users that are not the owner or in the `users` group don’t have any rights over this Template.

You can check what operations are allowed with each of the `USE`, `MANAGE` and `ADMIN` rights in the xml-rpc reference documentation. In general these rights are associated with the following operations:

- **USE**: Operations that do not modify the resource like listing it or using it (e.g., using an image or a virtual network). Typically you will grant `USE` rights to share your resources with other users of your group or with the rest of the users.

- **MANAGE**: Operations that modify the resource like stopping a virtual machine, changing the persistent attribute of an image or removing a lease from a network. Typically you will grant `MANAGE` rights to users that will manage your own resources.

- **ADMIN**: Special operations that are typically limited to administrators, like updating the data of a host or deleting an user group. Typically you will grant `ADMIN` permissions to those users with an administrator role.

**Important:** VirtualMachine objects allow you to set the permission level required for each specific action, for example you may want to require `USE` for the delete-recreate operation instead the default `ADMIN` right. You can override the default permissions for each action in oned.conf.

**Warning:** By default every user can update any permission group (owner, group or other) with the exception of the admin bit. There are some scenarios where it would be advisable to limit the other set (e.g. OpenNebula Zones so users can not break the group limits). In these situations the `ENABLE_OTHER_PERMISSIONS` attribute can be set to `NO` in `/etc/one/oned.conf` file.

**Changing Permissions with chmod**

The previous permissions can be updated with the chmod command. This command takes an octet as a parameter, following the octal notation of the Unix chmod command. The octet must be a three-digit base-8 number. Each digit, with a value between 0 and 7, represents the rights for the `owner`, `group` and `other`, respectively. The rights are represented by these values:

- The `USE` bit adds 4 to its total (in binary 100)
• The **MANAGE** bit adds 2 to its total (in binary 010)

• The **ADMIN** bit adds 1 to its total (in binary 001)

Let’s see some examples:

```bash
$ onetemplate show 0
...
PERMISSIONS
OWNER : um-
GROUP : u--
OTHER : ---

$ onetemplate chmod 0 664 -v
VMTEMPLATE 0: Permissions changed

$ onetemplate show 0
...
PERMISSIONS
OWNER : um-
GROUP : um-
OTHER : u--

$ onetemplate chmod 0 644 -v
VMTEMPLATE 0: Permissions changed

$ onetemplate show 0
...
PERMISSIONS
OWNER : um-
GROUP : u--
OTHER : u--

$ onetemplate chmod 0 607 -v
VMTEMPLATE 0: Permissions changed

$ onetemplate show 0
...
PERMISSIONS
OWNER : um-
GROUP : ---
OTHER : uma
```

### Setting Default Permissions with umask

The default permissions given to newly created resources can be set:

- Globally, with the **DEFAULT_UMASK** attribute in oned.conf
- Individually for each User, using the `oneuser umask` command.

These mask attributes work in a similar way to the Unix `umask` command. The expected value is a three-digit base-8 number. Each digit is a mask that disables permissions for the **owner**, **group** and **other**, respectively.

This table shows some examples:
2.5.2 Managing Permissions in Sunstone

Sunstone offers a convenient way to manage resources permissions. This can be done by selecting resources from a view (for example the templates view) and clicking on the update properties button. The update dialog lets the user conveniently set the resource’s permissions.

2.5.3 Locking Resources

OpenNebula can lock actions on a resource to prevent not intended operations, e.g. to not accidentally delete a VM. By default OpenNebula will lock all operations, but you can provide a fine grain lock by specifying the access level required by the action:

- **USE**: locks all possible actions.
- **MANAGE**: locks manage and admin actions.
- **ADMIN**: locks admin actions.

The following resources can be locked:

- VM
- NET
- IMAGE
- TEMPLATE
- DOCUMENT
- VROUTER
- MARKETPLACEAPP
Example:

```plaintext
$ oneimage lock 2
$ oneimage delete 2

$ oneimage unlock 2
```

**Warning:** The user ONEADMIN is not affected by locks and can perform the operation in any case.

### 2.6 Managing ACL Rules

The ACL authorization system enables fine-tuning of the allowed operations for any user, or group of users. Each operation generates an authorization request that is checked against the registered set of ACL rules. The core then can grant permission, or reject the request.

This allows administrators to tailor the user roles according to their infrastructure needs. For instance, using ACL rules you could create a group of users that can see and use existing virtual resources, but not create any new ones. Or grant permissions to a specific user to manage Virtual Networks for some of the existing groups, but not to perform any other operation in your cloud. Some examples are provided at the end of this guide.

Please note: the ACL rules is an advanced mechanism. For most use cases, you should be able to rely on the built-in resource permissions and the ACL Rules created automatically when a group is created, and when physical resources are added to a VDC.

#### 2.6.1 Understanding ACL Rules

Let's start with an example:

```plaintext
#5 IMAGE+TEMPLATE/@103 USE+MANAGE #0
```

This rule grants the user with ID 5 the right to perform USE and MANAGE operations over all Images and Templates in the group with id 103.

The rule is split in four components, separated by a space:

- **User** component is composed only by an ID definition.
- **Resources** is composed by a list of ‘+’ separated resource types, ‘/’ and an ID definition.
- **Rights** is a list of Operations separated by the ‘+’ character.
- **Zone** is an ID definition of the zones where the rule applies. This last part is optional, and can be ignored unless OpenNebula is configured in a federation.

The ID definition for User in a rule is written as:

- #<id> : for individual IDs
- @<id> : for a group ID
- * : for All

The ID definition for a Resource has the same syntax as the ones for Users, but adding:

- %<id> : for cluster IDs
Some more examples:

This rule allows all users in group 105 to create new virtual resources:

```
@105 VM+NET+IMAGE+TEMPLATE/* CREATE
```

The next one allows all users in the group 106 to use the Virtual Network 47. That means that they can instantiate VM templates that use this network.

```
@106 NET/#47 USE
```

**Note:** Note the difference between `* NET/#47 USE` vs `* NET/@47 USE` All Users can use NETWORK with ID 47 vs All Users can use NETWORKS belonging to the Group whose ID is 47

The following one allows users in group 106 to deploy VMs in Hosts assigned to the cluster 100

```
@106 HOST/%100 MANAGE
```

### 2.6.2 Managing ACL Rules via Console

The ACL rules are managed using the `oneacl command`. The ‘oneacl’ output looks like this:

```
$ oneacl list

  ID  USER RES_VHNIUTGDC0S+RMA RID OPE_UMAC ZONE
  0   @1 V--I-T---O-S----- *   ---c   *
  1   * ----------Z----- * u--- *
  2   * --------------MA * u--- *
  3   @1 -H-------------- * -m-- #0
  4   @1 --N----D-------- * u--- #0
  5   @106 ---I------------- #31 u--- #0
```

The rules shown correspond to the following ones:

```
@1 VM+IMAGE+TEMPLATE+DOCUMENT+SECGROUP/* CREATE *
* ZONE/* USE *
* MARKETPLACE+MARKETPLACEAPP/* USE *
@1 HOST/* MANAGE #0
@106 NET+DATASTORE/* USE #0
@106 IMAGE/#31 USE #0
```

The first five were created on bootstrap by OpenNebula, and the last one was created using oneacl:

```
$ oneacl create "@106 IMAGE/#31 USE"
ID: 5
```

The **ID** column identifies each rule’s ID. This ID is needed to delete rules, using ‘**oneacl delete <id>**’.

Next column is **USER**, which can be an individual user (#) or group (@) id; or all (*) users.

The **Resources** column lists the existing Resource types initials. Each rule fills the initials of the resource types it applies to.

- **V**: VM
- **H**: HOST
• N : NET
• I : IMAGE
• U : USER
• T : TEMPLATE
• G : GROUP
• D : DATASTORE
• C : CLUSTER
• O : DOCUMENT
• Z : ZONE
• S : SECURITY GROUP
• V : VDC
• R : VROUTER
• M : MARKETPLACE
• A : MARKETPLACEAPP

**RID** stands for Resource ID, it can be an individual object (#), group (@) or cluster (%) id; or all (*) objects.

The next **Operations** column lists the allowed operations initials.

• U : USE
• M : MANAGE
• A : ADMIN
• C : CREATE

And the last column, **Zone**, shows the zone(s) where the rule applies. It can be an individual zone id (#), or all (*) zone.

### 2.6.3 Managing ACLs via Sunstone

Sunstone offers a very intuitive and easy way of managing ACLs.

Select ACLs in the left-side menu to access a view of the current ACLs defined in OpenNebula:
This view is designed to easily understand what the purpose of each ACL is. You can create new ACLs by clicking on the New button at the top. A dialog will pop up:
In the creation dialog you can easily define the resources affected by the rule and the permissions that are granted upon them.

2.6.4 How Permission is Granted or Denied

**Note:** Visit the XML-RPC API reference documentation for a complete list of the permissions needed by each OpenNebula command.

For the internal Authorization in OpenNebula, there is an implicit rule:

- The oneadmin user, or users in the oneadmin group are authorized to perform any operation.

If the resource is one of type VM, NET, IMAGE, TEMPLATE, or DOCUMENT the object’s permissions are checked. For instance, this is an example of the oneimage show output:

```bash
$ oneimage show 2
IMAGE 2 INFORMATION
ID                  : 2
[...]
```
The output above shows that the owner of the image has USE and MANAGE rights.

If none of the above conditions are true, then the set of ACL rules is iterated until one of the rules allows the operation.

An important concept about the ACL set is that each rule adds new permissions, and they can’t restrict existing ones: if any rule grants permission, the operation is allowed.

This is important because you have to be aware of the rules that apply to a user and his group. Consider the following example: if a user #7 is in the group @108, with the following existing rule:

```
@108 IMAGE/#45 USE+MANAGE
```

Then the following rule won’t have any effect:

```
#7 IMAGE/#45 USE
```

### Special Authorization for Virtual Network Reservations

There is a special sub-type of Virtual Network: reservations. For these virtual networks the ACL system makes the following exceptions:

- ACL rules that apply to ALL (*) are ignored
- ACL rules that apply to a cluster (%) are ignored

The other ACL rules are enforced: individual (#) and group (@). The Virtual Network object’s permissions are also enforced as usual.

## 2.7 Managing Quotas

This guide will show you how to set the usage quotas for users and groups.

### 2.7.1 Overview

The quota system tracks user and group usage of system resources, and allows the system administrator to set limits on the usage of these resources. Quota limits can be set for:

- **users**, to individually limit the usage made by a given user.
- **groups**, to limit the overall usage made by all the users in a given group. This can be of special interest for the OpenNebula Zones and Virtual Data Center (VDC) components.

### 2.7.2 Which Resource can be limited?

The quota system allows you to track and limit usage on:

- **Datastores**, to control the amount of storage capacity allocated to each user/group for each datastore.
- **Compute**, to limit the overall memory, cpu or VM instances.
• **Network**, to limit the number of IPs a user/group can get from a given network. This is specially interesting for networks with public IPs, which usually are a limited resource.

• **Images**, you can limit how many VM instances from a given user/group are using a given image. You can take advantage of this quota when the image contains consumable resources (e.g. software licenses).

**Warning**: Only datastore size is consumed when using a Ceph backend, system disks will not be affected in this case. The reason is that this kind of datastores use the same space for system and for images, so OpenNebula can not know which space is used in each case.

### 2.7.3 Defining User/Group Quotas

Usage quotas are set in a traditional template syntax (either plain text or XML). The following table explains the attributes needed to set each quota:

#### Datastore Quotas. Attribute name: `DATASTORE`

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>ID of the Datastore to set the quota for</td>
</tr>
<tr>
<td>SIZE</td>
<td>Maximum size in MB that can be used in the datastore</td>
</tr>
<tr>
<td>IMAGE</td>
<td>Maximum number of images that can be created in the datastore</td>
</tr>
</tbody>
</table>

#### Compute Quotas. Attribute name: `VM`

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMS</td>
<td>Maximum number of VMs that can be created</td>
</tr>
<tr>
<td>MEMORY</td>
<td>Maximum memory in MB that can be requested by user/group VMs</td>
</tr>
<tr>
<td>CPU</td>
<td>Maximum CPU capacity that can be requested by user/group VMs</td>
</tr>
<tr>
<td>RUNNING VMS</td>
<td>Maximum number of VMs that can be running</td>
</tr>
<tr>
<td>RUNNING MEMORY</td>
<td>Maximum memory in MB that can be running by user/group VMs</td>
</tr>
<tr>
<td>RUNNING CPU</td>
<td>Maximum CPU capacity that can be running by user/group VMs</td>
</tr>
<tr>
<td>SYSTEM_DISK_SIZE</td>
<td>Maximum size (in MB) of system disks that can be requested by user/group VMs</td>
</tr>
</tbody>
</table>

**Note**: Running quotas will be increased or decreased depending on the state of the Virtual Machine. The states in which the machine is counted as **ACTIVE “Running”** are **ACTIVE, HOLD, PENDING and CLONING**.

#### Network Quotas. Attribute name: `NETWORK`

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>ID of the Network to set the quota for</td>
</tr>
<tr>
<td>LEASES</td>
<td>Maximum IPs that can be leased from the Network</td>
</tr>
</tbody>
</table>

---

2.7. Managing Quotas 58
Image Quotas. Attribute name: IMAGE

<table>
<thead>
<tr>
<th>IMAGE Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID</td>
<td>ID of the Image to set the quota for</td>
</tr>
<tr>
<td>RVMS</td>
<td>Maximum VMs that can used this image at the same time</td>
</tr>
</tbody>
</table>

For each quota, there are two special limits:

- `-1` means that the **default quota** will be used
- `-2` means **unlimited**

**Warning:** Each quota has an usage counter associated named `<QUOTA_NAME>_USED`. For example, MEMORY_USED means the total memory used by user/group VMs, and its associated quota is MEMORY.

The following template shows a quota example for a user in plain text. It limits the overall usage in Datastore 0 to 20Gb (for an unlimited number of images); the number of VMs that can be created to 4 with a maximum memory to 2G and 5 CPUs; the number of leases from network 1 to 4; and image 1 can only be used by 3 VMs at the same time:

```plaintext
DATASTORE=[
  ID="1",
  IMAGES="-2",
  SIZE="20480"
]

VM=[
  CPU="5",
  MEMORY="2048",
  VMS="4",
  SYSTEM_DISK_SIZE="-1"
]

NETWORK=[
  ID="1",
  LEASES="4"
]

IMAGE=[
  ID="1",
  RVMS="3"
]

IMAGE=[
  ID="2",
  RVMS="-2"
]
```

**Warning:** Note that whenever a network, image, datastore or VM is used the corresponding quota counters are created for the user with an unlimited value. This allows to track the usage of each user/group even when quotas are not used.
2.7.4 Setting User/Group Quotas

User/group quotas can be easily set up either through the command line interface or Sunstone. Note that you need `MANAGE` permissions to set a quota of a user, and `ADMIN` permissions to set the quota of a group. In this way, by default, only one admin can set quotas for a group, but if you define a group manager she can set specific usage quotas for the users on her group (so distributing resources as required). You can always change this behavior setting the appropriate ACL rules.

To set the quota for a user, e.g. `userA`, just type:

```bash
$ oneuser quota userA
```

This will open an editor session to edit a quota template (with some tips about the syntax).

**Warning:** Usage metrics are included for information purposes (e.g. `CPU_USED`, `MEMORY_USED`, `LEASES_USED`...) you cannot modify them

**Warning:** You can add as many resource quotas as needed even if they have not been automatically initialized.

Similarly, you can set the quotas for group A with:

```bash
$ onegroup quota groupA
```

There is a `batchquota` command that allows you to set the same quotas for several users or groups:

```bash
$ oneuser batchquota userA,userB,35
$ onegroup batchquota 100..104
```

You can also set the user/group quotas in Sunstone through the user/group tab.
2.7.5 Setting Default Quotas

There are two default quota limit templates, one for users and another for groups. This template applies to all users/groups, unless they have an individual limit set.

Use the `oneuser/onegroup defaultquota` command.

```
$ oneuser defaultquota
```

2.7.6 Checking User/Group Quotas

Quota limits and usage for each user/group is included as part of its standard information, so it can be easily check with the usual commands. Check the following examples:
$ oneuser show uA

USER 2 INFORMATION
ID : 2
NAME : uA
GROUP : gA
PASSWORD : a9993e364706816aba3e25717850c26c9cd0d89d
AUTH_DRIVER : core
ENABLED : Yes

USER TEMPLATE

VMS USAGE & QUOTAS

<table>
<thead>
<tr>
<th>VMS</th>
<th>MEMORY</th>
<th>CPU</th>
<th>SYSTEM_DISK_SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>1M</td>
<td>-</td>
</tr>
</tbody>
</table>

VMS USAGE & QUOTAS - RUNNING

<table>
<thead>
<tr>
<th>RUNNING VMS</th>
<th>RUNNING MEMORY</th>
<th>RUNNING CPU</th>
<th>SYSTEM_DISK_SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1M</td>
<td>2M</td>
<td>2.00</td>
</tr>
</tbody>
</table>

DATASTORE USAGE & QUOTAS

NETWORK USAGE & QUOTAS

IMAGE USAGE & QUOTAS

And for the group:

$ onegroup show gA

GROUP 100 INFORMATION
ID : 100
NAME : gA

USERS

ID
2
3

VMS USAGE & QUOTAS

<table>
<thead>
<tr>
<th>VMS</th>
<th>MEMORY</th>
<th>CPU</th>
<th>SYSTEM_DISK_SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>1M</td>
<td>-</td>
</tr>
</tbody>
</table>

VMS USAGE & QUOTAS - RUNNING

<table>
<thead>
<tr>
<th>RUNNING VMS</th>
<th>RUNNING MEMORY</th>
<th>RUNNING CPU</th>
<th>SYSTEM_DISK_SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1M</td>
<td>2M</td>
<td>2.00</td>
</tr>
</tbody>
</table>

DATASTORE USAGE & QUOTAS

NETWORK USAGE & QUOTAS

IMAGE USAGE & QUOTAS

This information is also available through Sunstone as part of the user/group information.

2.7. Managing Quotas
2.8 Accounting Client

The accounting toolset visualizes and reports resource usage data. This accounting tool addresses the accounting of the virtual resources. It includes resource consumption of the virtual machines as reported from the hypervisor.

2.8.1 Usage

oneacct - prints accounting information for virtual machines

Usage: oneacct [options]

- -start TIME First day of the data to retrieve
- -e, --end TIME Last day of the data to retrieve
- u, --userfilter user User name or id to filter the results
- g, --group group Group name or id to filter the results
- H, --host HOST Host name or id to filter the results
--xpath XPATH_EXPRESSION Xpath expression to filter the results. For example: oneacct --xpath 'HISTORY[ETIME>0]' 
- x, --xml Show the resource in xml format
- j, --json Show the resource in json format
--split Split the output in a table for each VM
- v, --verbose Verbose mode
- h, --help Show this message
- V, --version Show version and copyright information
--describe Describe list columns
- l, --list x,y,z Selects columns to display with list command
--csv Write table in csv format
--user name User name used to connect to OpenNebula
--password password Password to authenticate with OpenNebula
--endpoint endpoint URL of OpenNebula XML-RPC front-end

The time can be written as month/day/year hour:minute:second, or any other similar format, e.g. month/day hour:minute.

To integrate this tool with other systems you can use - j, - x or --csv flags to get all the information in an easy computer readable format.

2.8.2 Accounting Output

The oneacct command shows individual Virtual Machine history records. This means that for a single VM you may get several accounting entries, one for each migration or stop/suspend action. A resize or disk/nic attachment will also create a new entry.

Each entry contains the complete information of the Virtual Machine, including the Virtual Machine monitoring information. By default, only network consumption is reported, see the Tuning & Extending section for more information.

When the results are filtered with the - s and/or - e options, all the history records that were active during that time interval are shown, but they may start or end outside that interval.

For example, if you have a VM that was running from May 1st to June 1st, and you request the accounting information with this command:

```
$ oneacct - s 05/01 - e 06/01
Showing active history records from 2016-05-01 00:00:00 +0200 to 2016-06-02 00:00:00 +0200
# User 0
```
The record shows the complete history record, and total network consumption. It will not reflect the consumption made only during the month of May.

Other important thing to pay attention to is that active history records, those with END_TIME ‘-‘, refresh their monitoring information each time the VM is monitored. Once the VM is shut down, migrated or stopped, the END_TIME is set and the monitoring information stored is frozen. The final values reflect the total for accumulative attributes, like NETRX/NETTX.

### Sample Output

Obtaining all the available accounting information:

```
$ oneacct
# User 0
```

<table>
<thead>
<tr>
<th>VID</th>
<th>HOSTNAME</th>
<th>ACTION</th>
<th>REAS</th>
<th>START_TIME</th>
<th>END_TIME</th>
<th>MEMORY</th>
<th>CPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>host01</td>
<td>terminate</td>
<td>user</td>
<td>05/27 16:40:47</td>
<td>05/27 17:09:20</td>
<td>1024M</td>
<td>0.1</td>
</tr>
<tr>
<td>0K</td>
<td>0K</td>
<td>10.4G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>host02</td>
<td>none</td>
<td>none</td>
<td>05/27 17:09:28</td>
<td>05/27 17:09:28</td>
<td></td>
<td>256M</td>
</tr>
<tr>
<td>2.4M</td>
<td>1.3K</td>
<td>10G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The columns are:

- VID: Virtual Machine ID
- HOSTNAME: Hostname of the VM
- ACTION: Action performed
- REAS: Reason for the action
- START_TIME: Start time of the action
- END_TIME: End time of the action
- MEMORY: Amount of memory used
- CPU: Amount of CPU used
- NETRX: Total input network bytes
- NETTX: Total output network bytes
- DISK: Total disk usage

---

2.8. Accounting Client 64
<table>
<thead>
<tr>
<th>Column</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>VID</td>
<td>Virtual Machine ID</td>
</tr>
<tr>
<td>HOSTNAME</td>
<td>Host name</td>
</tr>
<tr>
<td>ACTION</td>
<td>Virtual Machine action that created a new history record</td>
</tr>
<tr>
<td>REASON</td>
<td>VM state change reason:</td>
</tr>
<tr>
<td></td>
<td>• none: Virtual Machine still running</td>
</tr>
<tr>
<td></td>
<td>• erro: The VM ended in error</td>
</tr>
<tr>
<td></td>
<td>• user: VM action started by the user</td>
</tr>
<tr>
<td>START_TIME</td>
<td>Start time</td>
</tr>
<tr>
<td>END_TIME</td>
<td>End time</td>
</tr>
<tr>
<td>MEMORY</td>
<td>Assigned memory. This is the requested memory, not the monitored memory consumption</td>
</tr>
<tr>
<td>CPU</td>
<td>Number of CPUs. This is the requested number of Host CPU share, not the monitored cpu usage</td>
</tr>
<tr>
<td>NETRX</td>
<td>Data received from the network</td>
</tr>
<tr>
<td>NETTX</td>
<td>Data sent to the network</td>
</tr>
</tbody>
</table>

Obtaining the accounting information for a given user

```bash
$ oneacct -u 0 --split
# User 0

<table>
<thead>
<tr>
<th>VID</th>
<th>HOSTNAME</th>
<th>ACTION</th>
<th>REASON</th>
<th>START_TIME</th>
<th>END_TIME</th>
<th>MEMORY</th>
<th>CPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>host01</td>
<td>none</td>
<td>user</td>
<td>05/09 19:20:42</td>
<td>05/09 19:35:23</td>
<td>1024M</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29.8M 638.8K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>host01</td>
<td>nic-attach</td>
<td>user</td>
<td>05/17 17:10:57</td>
<td>05/17 17:12:48</td>
<td>256M</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19.2K 15.4K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>36.9K 25K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>host01</td>
<td>nic-detach</td>
<td>user</td>
<td>05/17 17:12:48</td>
<td>05/17 17:13:48</td>
<td>256M</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>36.9K 25K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>51.2K 36.4K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>host01</td>
<td>nic-detach</td>
<td>user</td>
<td>05/17 17:13:48</td>
<td>05/17 17:14:54</td>
<td>256M</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>79.8K 61.7K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>79.8K 61.7K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>host01</td>
<td>terminate-hard</td>
<td>user</td>
<td>05/17 17:17:27</td>
<td>05/17 17:37:52</td>
<td>256M</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>124.6K 85.9K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>host02</td>
<td>none</td>
<td>none</td>
<td>05/27 17:09:28</td>
<td></td>
<td>256M</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.4M 1.3K 10G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.8. Accounting Client
In case you use CSV output (--csv) you will get a header with the name of each column and then the data. For example:

```
$ oneacct --csv
UID,VID,HOSTNAME,ACTION,REASON,START_TIME,END_TIME,MEMORY,CPU,NETRX,NETTX,DISK
0,12,host01,none,user,05/09 19:20:42,05/09 19:35:23,1024M,1,29.8M,638.8K,0K
0,13,host01,nic-attach,user,05/17 17:10:57,05/17 17:12:48,256M,0.1,19.2K,15.4K,8G
0,13,host01,nic-detach,user,05/17 17:12:48,05/17 17:13:48,256M,0.1,36.9K,25K,8G
0,13,host01,nic-attach,user,05/17 17:13:48,05/17 17:14:54,256M,0.1,51.2K,36.4K,8G
0,13,host01,nic-detach,user,05/17 17:14:54,05/17 17:17:19,256M,0.1,79.8K,61.7K,8G
0,13,host01,nic-attach,user,05/17 17:17:19,05/17 17:17:27,256M,0.1,79.8K,61.7K,8G
0,13,host01,terminate-hard,user,05/17 17:17:27,05/17 17:37:52,256M,0.1,124.6K,85.9K,8G
0,14,host02,nic-attach,user,05/17 17:38:16,05/17 17:40:00,256M,0.1,16.5K,13.2K,8G
0,14,host01,poweroff,user,05/17 17:40:00,05/17 17:53:40,256M,0.1,38.3K,18.8K,8G
0,14,host02,terminate-hard,user,05/17 17:55:55,05/18 14:54:19,256M,0.1,1M,27.3K,8G
0,29,host02,none,none,05/27 17:09:28,--,256M,1,2.4M,1.3K,10G
```

**Output Reference**

If you execute oneacct with the −x option, you will get an XML output defined by the following xsd:

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema" elementFormDefault="qualified"


  <xs:element name="HISTORY_RECORDS">
    <xs:complexType>
      <xs:sequence maxOccurs="1" minOccurs="1">
        <xs:element ref="HISTORY" maxOccurs="unbounded" minOccurs="0"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>

  <xs:element name="HISTORY">
    <xs:complexType>
      <xs:sequence>
        <xs:element name="OID" type="xs:integer"/>
        <xs:element name="SEQ" type="xs:integer"/>
        <xs:element name="HOSTNAME" type="xs:string"/>
        <xs:element name="HID" type="xs:integer"/>
        <xs:element name="CID" type="xs:integer"/>
        <xs:element name="STIME" type="xs:integer"/>
        <xs:element name="ETIME" type="xs:integer"/>
        <xs:element name="VM_MAD" type="xs:string"/>
        <xs:element name="TM_MAD" type="xs:string"/>
        <xs:element name="DS_ID" type="xs:integer"/>
        <xs:element name="PSTIME" type="xs:integer"/>
        <xs:element name="PETIME" type="xs:integer"/>
        <xs:element name="RSTIME" type="xs:integer"/>
        <xs:element name="RETIME" type="xs:integer"/>
        <xs:element name="ESTIME" type="xs:integer"/>
        <xs:element name="EETIME" type="xs:integer"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>

  <!-- REASON values:
```
```
NONE = 0 History record is not closed yet
ERROR = 1 History record was closed because of an error
USER = 2 History record was closed because of a user action

<!-- ACTION values:
NONE_ACTION = 0
MIGRATE_ACTION = 1
LIVE_MIGRATE_ACTION = 2
SHUTDOWN_ACTION = 3
SHUTDOWN_HARD_ACTION = 4
UNDEPLOY_ACTION = 5
UNDEPLOY_HARD_ACTION = 6
HOLD_ACTION = 7
RELEASE_ACTION = 8
STOP_ACTION = 9
SUSPEND_ACTION = 10
RESUME_ACTION = 11
BOOT_ACTION = 12
DELETE_ACTION = 13
DELETE_RECREATE_ACTION = 14
REBOOT_ACTION = 15
REBOOT_HARD_ACTION = 16
RESCHED_ACTION = 17
UNRESCHED_ACTION = 18
POWEROFF_ACTION = 19
POWEROFF_HARD_ACTION = 20
DISK_ATTACH_ACTION = 21
DISK_DETACH_ACTION = 22
NIC_ATTACH_ACTION = 23
NIC_DETACH_ACTION = 24
DISK_SNAPSHOT_CREATE_ACTION = 25
DISK_SNAPSHOT_DELETE_ACTION = 26
TERMINATE_ACTION = 27
TERMINATE_HARD_ACTION = 28
-->

<xs:element name="REASON" type="xs:integer"/>

<!-- ACTION values:
NONE_ACTION = 0
MIGRATE_ACTION = 1
LIVE_MIGRATE_ACTION = 2
SHUTDOWN_ACTION = 3
SHUTDOWN_HARD_ACTION = 4
UNDEPLOY_ACTION = 5
UNDEPLOY_HARD_ACTION = 6
HOLD_ACTION = 7
RELEASE_ACTION = 8
STOP_ACTION = 9
SUSPEND_ACTION = 10
RESUME_ACTION = 11
BOOT_ACTION = 12
DELETE_ACTION = 13
DELETE_RECREATE_ACTION = 14
REBOOT_ACTION = 15
REBOOT_HARD_ACTION = 16
RESCHED_ACTION = 17
UNRESCHED_ACTION = 18
POWEROFF_ACTION = 19
POWEROFF_HARD_ACTION = 20
DISK_ATTACH_ACTION = 21
DISK_DETACH_ACTION = 22
NIC_ATTACH_ACTION = 23
NIC_DETACH_ACTION = 24
DISK_SNAPSHOT_CREATE_ACTION = 25
DISK_SNAPSHOT_DELETE_ACTION = 26
TERMINATE_ACTION = 27
TERMINATE_HARD_ACTION = 28
-->

<xs:element name="ACTION" type="xs:integer"/>

<xs:element name="VM">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="ID" type="xs:integer"/>
      <xs:element name="UID" type="xs:integer"/>
      <xs:element name="GID" type="xs:integer"/>
      <xs:element name="UNAME" type="xs:string"/>
      <xs:element name="GNAME" type="xs:string"/>
      <xs:element name="NAME" type="xs:string"/>
      <xs:element name="PERMISSIONS" minOccurs="0" maxOccurs="1">
        <xs:complexType>
          <xs:sequence>
            <xs:element name="OWNER_U" type="xs:integer"/>
            <xs:element name="OWNER_M" type="xs:integer"/>
            <xs:element name="OWNER_A" type="xs:integer"/>
            <xs:element name="GROUP_U" type="xs:integer"/>
            <xs:element name="GROUP_M" type="xs:integer"/>
            <xs:element name="GROUP_A" type="xs:integer"/>
            <xs:element name="OTHER_U" type="xs:integer"/>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:element>

2.8. Accounting Client 67
<xs:element name="OTHER_M" type="xs:integer"/>
<xs:element name="OTHER_A" type="xs:integer"/>
</xs:sequence>
</xs:complexType>
</xs:element>
<xs:element name="LAST_POLL" type="xs:integer"/>

<!-- STATE values, see http://docs.opennebula.org/stable/user/references/vm_states.html -->
<xs:element name="STATE" type="xs:integer"/>

<!-- LCM_STATE values, this sub-state is relevant only when STATE is ACTIVE (4) see http://docs.opennebula.org/stable/user/references/vm_states.html -->
<xs:element name="LCM_STATE" type="xs:integer"/>
<xs:element name="PREV_STATE" type="xs:integer"/>
<xs:element name="PREV_LCM_STATE" type="xs:integer"/>
<xs:element name="RESCHED" type="xs:integer"/>
<xs:element name="STIME" type="xs:integer"/>
<xs:element name="ETIME" type="xs:integer"/>
<xs:element name="DEPLOY_ID" type="xs:string"/>
<xs:element name="MONITORING">
  <!-- Accounting Client 68

  -- Percentage of 1 CPU consumed (two fully consumed cpu is 200) ->
  <xs:element name="CPU" type="xs:decimal" minOccurs="0" maxOccurs="1"/>

  -- MEMORY consumption in kilobytes ->
  <xs:element name="MEMORY" type="xs:integer" minOccurs="0" maxOccurs="1"/>

  -- NETTX: Sent bytes to the network ->
  <xs:element name="NETTX" type="xs:integer" minOccurs="0" maxOccurs="1"/>

  -- NETRX: Received bytes from the network ->
  <xs:element name="NETRX" type="xs:integer" minOccurs="0" maxOccurs="1"/>

  -- unbounded"
  <xs:complexType>
    <xs:all>
      <!-- Percentage of 1 CPU consumed (two fully consumed cpu is 200) ->
      <xs:element name="CPU" type="xs:decimal" minOccurs="0" maxOccurs="1"/>

      <!-- MEMORY consumption in kilobytes ->
      <xs:element name="MEMORY" type="xs:integer" minOccurs="0" maxOccurs="1"/>

      <!-- NETTX: Sent bytes to the network ->
      <xs:element name="NETTX" type="xs:integer" minOccurs="0" maxOccurs="1"/>

      <!-- NETRX: Received bytes from the network ->
      <xs:element name="NETRX" type="xs:integer" minOccurs="0" maxOccurs="1"
    </xs:all>
  </xs:complexType>
  -->
</xs:element>
<xs:element name="TEMPLATE" type="xs:anyType"/>
<xs:element name="USER_TEMPLATE" type="xs:anyType"/>
<xs:element name="HISTORY_RECORDS" minOccurs="0" maxOccurs="unbounded">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="SNAPSHOTS" minOccurs="0" maxOccurs="unbounded">
          <xs:complexType>
            <xs:sequence>
              <!-- Percentage of 1 CPU consumed (two fully consumed cpu is 200) ->
              <xs:element name="CPU" type="xs:decimal" minOccurs="0" maxOccurs="1"/>

              <!-- MEMORY consumption in kilobytes ->
              <xs:element name="MEMORY" type="xs:integer" minOccurs="0" maxOccurs="1"/>

              <!-- NETTX: Sent bytes to the network ->
              <xs:element name="NETTX" type="xs:integer" minOccurs="0" maxOccurs="1"/>

              <!-- NETRX: Received bytes from the network ->
              <xs:element name="NETRX" type="xs:integer" minOccurs="0" maxOccurs="1"
            </xs:sequence>
        </xs:complexType>
    </xs:sequence>
  </xs:complexType>
</xs:element>
2.8.3 Sunstone

Sunstone also displays information about accounting. Information is accessible via the User dialogs for the user and admin views. The cloud view can access the metering information in the dashboard, whereas the group admin user can access them under the users section.
There are two kinds of monitoring values:

- **Instantaneous values**: For example, `VM/CPU` or `VM/MEMORY` show the memory consumption last reported by the monitoring probes.
- **Accumulative values**: For example, `VM/NETRX` and `VM/NETTX` show the total network consumption since the history record started.

Developers interacting with OpenNebula using the Ruby bindings can use the `VirtualMachinePool.accounting` method to retrieve accounting information filtering and ordering by multiple parameters.
2.9 Showback

The showback toolset reports resource usage cost, and allows the integration with chargeback and billing platforms. The toolset generates showback reports using the information retrieved from OpenNebula.

2.9.1 Set the VM Cost

Each VM Template can optionally define a cost (see the syntax here). The cost is defined as **cost per cpu per hour**, and **cost per memory MB per hour**. The cost units are abstract and their equivalent to monetary or other cost metrics have to be defined in each deployment.

Using this cost schema allows the users to resize the Virtual Machine instances.
There is a default cost that will be applied to VM Templates without a cost defined. It can be set in the oned.conf file.

**Warning:** If your users can access the Sunstone ‘user’ view, it’s important to set a default cost. These users can manage their own Templates, which won’t have a specific cost assigned.

### 2.9.2 Calculate Monthly Reports

Before the cost reports can be seen by the users, the administrator has to generate them. To create the monthly cost reports, use the `oneshowback` command:

```bash
$ oneshowback calculate -h
Usage: oneshowback [options]
  -s, --start TIME First month of the data
  -e, --end TIME Last month of the data
```

When this command is executed, the OpenNebula core reads all the accounting records, and calculates the total cost for each month. The records include the total cost of the month, and basic information about the VM and its owner. This information is then stored in the database, to be consumed with the `oneshowback list` command.

The monthly cost of each VM is calculated as the sum of:

- `CPU_COST * CPU * HOURS`
• MEMORY_COST * MEMORY * HOURS
• DISK_COST * DISK_SIZE * HOURS

The number of hours is calculated as the total number of hours that a VM has been running. The time a VM is in other states, such as pending, poweroff, or stopped does not count towards the cost.

If the time range includes the current month, OpenNebula will calculate the cost up to today’s date. It is up to the administrators to leave the current month out of the showback records, to update it daily, or hourly. In any case, it is important to re-calculate it when the month ends. This operation can be easily automated by a cron job.

The oneshowback command can only be executed by the oneadmin user.

Some examples:

To calculate all records, starting from March up to today:

```bash
$ oneshowback calculate --start "03/2016"
```

To calculate only September:

```bash
$ oneshowback calculate --start "09/2016" --end "09/2016"
```

**Note:** This is a resource intensive operation. For big deployments, it is recommended to use the `--start` option to process only the last missing months.

**Note:** Existing records can be re-calculated. This can be useful to update old records when a VM is renamed, or the owner is changed. In this case, the cost of previous months will be also assigned to the new user.

### 2.9.3 Retrieve Monthly Reports

Any user or administrator can see their monthly showback reports from the CLI or Sunstone:
## USAGE

```
list
```

Returns the showback records

valid options: start_time, end_time, userfilter, group, xml, json, verbose, help, version, describe, list, csv, user, password, endpoint

## OPTIONS

```
-s, --start TIME
-e, --end TIME
-u, --userfilter user
-g, --group group
-x, --xml
-j, --json
-v, --verbose
-h, --help
-V, --version
--describe
```

First month of the data

Last month of the data

User name or id to filter the results

Group name or id to filter the results

Show the resource in xml format

Show the resource in json format

Verbose mode

Show this message

Show version and copyright information

Describe list columns
2.9.4 Disable Showback in Sunstone

Showback reports can be disabled in any of the Sunstone views modifying the yaml file of those views. These files can be found in /etc/one/sunstone-views

```yaml
... features:    showback: false
```

2.9.5 Tuning & Extending

To integrate the showback reports with external tools, you can get the CLI output as xml, json, or csv data.

```
$ oneshowback list -u cloud_user --list YEAR,MONTH,VM_ID,COST --csv
YEAR,MONTH,VM_ID,COST
2015,10,4258,1824279.62
2015,10,4265,433749.03
2015,11,4258,34248600
```

Developers interacting with OpenNebula using the Ruby bindings can use the VirtualMachinePool.showback method to retrieve showback information filtering and ordering by multiple parameters.
3.1 Overview

This chapter contains documentation on how to create and manage Virtual Networks, how to define and manage Security Groups, which will allow users and administrators to define firewall rules and apply them to the Virtual Machines, and how to create and manage Virtual Routers which are an OpenNebula resource that provide routing across Virtual Networks.

3.1.1 How Should I Read This Chapter

Before reading this chapter, you should have already installed your Frontend, the KVM Hosts or vCenter node and have an OpenNebula cloud up and running with at least one virtualization node.

3.1.2 Hypervisor Compatibility

<table>
<thead>
<tr>
<th>Section</th>
<th>Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual Networks</td>
<td>This Section applies to all Hypervisors</td>
</tr>
<tr>
<td>Security Groups</td>
<td>This Section applies to KVM and LXD</td>
</tr>
<tr>
<td>Virtual Routers</td>
<td>This Section applies to all Hypervisors</td>
</tr>
</tbody>
</table>

3.2 Virtual Networks

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– Using a Virtual Network
  * Manual Attach a Virtual Machine to a Virtual Network
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  * Attach a Virtual Machine to a NIC Alias
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– NSX Specific
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  * Deleting logical switches
  * Attaching logical switches to VMs
  * Detaching logical switches to VMs
  * Limitations

A host is connected to one or more networks that are available to the virtual machines through the corresponding bridges. OpenNebula allows the creation of Virtual Networks by mapping them on top of the physical ones.

### 3.2.1 Virtual Network Definition

A Virtual Network definition consists of three different parts:

- The **underlying physical network infrastructure** that will support it, including the network driver.
- The **logical address space** available. Addresses associated to a Virtual Network can be IPv4, IPv6, dual stack IPv4-IPv6 or Ethernet.
- The **guest configuration attributes** to setup the Virtual Machine network, that may include for example network masks, DNS servers or gateways.

**Physical Network Attributes**

To define a Virtual Network include:

- **NAME** to refer this Virtual Network.
• **VN_MAD** the driver to implement this Virtual Network. Depending on the driver you may need to set additional attributes, check the following to get more details:
  
  – Define a bridged network
  – Define a 802.1Q network
  – Define a VXLAN network
  – Define a OpenvSwitch network

• QoS parameters (optional) for each NIC attached to the network, to limit the inbound/outbound average and peak bandwidths as well as the burst data size that can be transmitted at peak speed (see more details here).

For example, to define a 802.1Q Virtual Network you would add:

```
NAME = "Private Network"
VN_MAD = "802.1Q"
PHYDEV = "eth0"

OUTBOUND_AVG_BW = "1000"
OUTBOUND_PEAK_BW = "1500"
OUTBOUND_PEAK_KB = "2048"
```

### Address Space

The addresses available in a Virtual Network are defined by one or more Address Ranges (AR). Each AR defines a continuous address range and optionally, configuration attributes that will override the first level attributes defined in the Virtual Network. There are four types of ARs:

• **IPv4**, to define a contiguous IPv4 address set (classless), see more details here
• **IPv6**, to define global and ULA IPv6 networks, see full details here
• **IPv6 no-SLAAC**, to define fixed 128 bits IPv6 address, see here
• **Dual stack**, each NIC in the network will get both a IPv4 and a IPv6 address (SLAAC or no-SLAAC), see more here
• **Ethernet**, just MAC addresses are generated for the VMs. You should use this AR when an external service is providing the IP addresses, such a DHCP server, see more details here

For example, to define the IPv4 address range 10.0.0.150 - 10.0.0.200

```
AR=[
    TYPE = "IP4",
    IP = "10.0.0.150",
    SIZE = "51",
]
```

### Guest Configuration Attributes (Context)

To setup the guest network, the Virtual Network may include additional information to be injected into the VM at boot time. These contextualization attributes may include for example network masks, DNS servers or gateways. For example, to define a gateway and DNS server for the virtual machines in the Virtual Network, simply add:

```
DNS = "10.0.0.23"
GATEWAY = "10.0.0.1"
```
These attributes are automatically added to the VM and processed by the context packages. Virtual Machines just need to add:

```
CONTEXT = [
    NETWORK="yes"
]
```

*See here for a full list of supported attributes*

### Virtual Network Definition Example

Getting all the three pieces together we get:

```
NAME     = "Private"
VN_MAD   = "802.1Q"
PHYDEV   = "eth0"

AR=[
    TYPE = "IP4",
    IP   = "10.0.0.150",
    SIZE = "51"
]

DNS      = "10.0.0.23"
GATEWAY  = "10.0.0.1"

DESCRIPTION = "A private network for VM inter-communication"
```

This file will create an IPv4 network using VLAN tagging, the VLAN ID in this case is assigned by OpenNebula. The network will lease IPs in the range 10.0.0.150 - 10.0.0.200. Virtual Machines in this network will get a lease in the range and configure DNS servers to 10.0.0.23 and 10.0.0.1 as default gateway.

*See here for more examples*

### 3.2.2 Adding and Deleting Virtual Networks

**Note:** This guide uses the CLI command `onevnet`, but you can also manage your virtual networks using Sunstone. Select the Network tab, and there you will be able to create and manage your virtual networks in a user friendly way.

There are three different ways for creating a network:

- **Creating** the network from scratch.
- **Making a reservation** from an existing network.
- **Instantiating** a network template.

End users typically use the last two ways, instantiation and reservation. The administrator can define a network template for being instantiated later by the end user or create a virtual network where the end user can make a reservation from.
To create a new network from scratch put its configuration in a file, for example using the contents above, and then execute:

```
$ onevnet create priv.net
ID: 4
```

You can delete a virtual network using its ID or name:

```
$ onevnet delete 0
$ onevnet delete "Private"
```

To list the virtual networks in the system use `onevnet list`:

```
$ onevnet list

<table>
<thead>
<tr>
<th>ID</th>
<th>USER</th>
<th>GROUP</th>
<th>NAME</th>
<th>CLUSTER</th>
<th>BRIDGE</th>
<th>LEASES</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>admin</td>
<td>oneadmin</td>
<td>Private</td>
<td>0,100</td>
<td>onebr.10</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>admin</td>
<td>oneadmin</td>
<td>Public</td>
<td>0,101</td>
<td>vbr0</td>
<td>0</td>
</tr>
</tbody>
</table>
```

In the output above, USER is the owner of the network and LEASES the number of addresses assigned to a virtual machine or reserved.

You can check the details of a Virtual Network with the `onevnet show` command:

```
$ onevnet show 1
VIRTUAL NETWORK 4 INFORMATION
ID : 4
NAME : Private
USER : ruben
GROUP : oneadmin
CLUSTERS : 0
BRIDGE : onebr4
VN_MAD : 802.1Q
PHYSICAL DEVICE: eth0
VLAN ID : 6
USED LEASES : 0
```
PERMISSIONS
OWNER : um-
GROUP : ---
OTHER : ---

VIRTUAL NETWORK TEMPLATE
BRIDGE="onebr4"
DESCRIPTION="A private network for VM inter-communication"
DNS="10.0.0.23"
GATEWAY="10.0.0.1"
PHYDEV="eth0"
SECURITY_GROUPS="0"
VN_MAD="802.1Q"

ADDRESS RANGE POOL
AR 0
SIZE : 51
LEASES : 0

<table>
<thead>
<tr>
<th>RANGE</th>
<th>FIRST</th>
<th>LAST</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAC</td>
<td>02:00:0a:00:00:96</td>
<td>02:00:0a:00:00:08</td>
</tr>
<tr>
<td>IP</td>
<td>10.0.0.150</td>
<td>10.0.0.200</td>
</tr>
</tbody>
</table>

Check the onevnet command help or the reference guide for more options to list the virtual networks.

**Virtual Network Tips**

- You may have some used IPs in a VNET so you do not want them to be assigned. You can add as many ARs as you need to implement these address gaps. Alternatively you can put address on hold to prevent them to be assigned.
- ARs can be of SIZE = 1 to define single addresses lease scheme.
- ARs does not need to be of the same type or belong to the same IP network. To accommodate this use case you can overwrite context attributes in the AR, for example adding attributes like NETWORK_MASK or DNS in the AR definition.
- **Super-netting**, you can even combine ARs overwriting the physical attributes, e.g. BRIDGE or VLAN_ID. This way a Virtual Network can be a logical super-net, e.g. DMZ, that can be implemented through multiple VLANs each using a different hypervisor bridge.
- There are no need to plan all your IP assignment plan beforehand, ARs can be added and modified after the Virtual Network is created, see below.
- Orphan vnets (i.e images not referenced by any template) can be shown with onevnet orphans command.

**3.2.3 Updating a Virtual Network**

After creating a Virtual Network, you can use the onevnet update command to update the following attributes:

- Any attribute corresponding to the context or description.
- Physical network configuration attributes, e.g. PHYDEV or VLAN_ID.
- Any custom tag.

Also the name of the Virtual Network can be changed with onevnet rename command.
3.2.4 Managing Address Ranges

Addresses are structured in Address Ranges (AR). Address Ranges can be dynamically added or removed from a Virtual Network. In this way, you can easily add new addresses to an existing Virtual Network if the current addresses are exhausted.

Adding and Removing Address Ranges

A new AR can be added using exactly the same definition parameters as described above. For example the following command will add a new AR of 20 IP addresses:

```bash
onevnet addar Private --ip 10.0.0.200 --size 20
```

In the same way you can remove an AR:

```bash
onevnet rmar Private 2
```

Updating Address Ranges

You can update the following attributes of an AR:

- **SIZE**: assigned addresses cannot fall outside of the range.
- **IPv6 prefix**: `GLOBAL_PREFIX` and `ULA_PREFIX`
- Any custom attribute that may override the Virtual Network defaults.

The following command shows how to update an AR using the CLI, an interactive editor session will be stated:

```bash
onevnet updatear Private 0
```

Hold and Release Leases

Addresses can be temporarily be marked as **hold**. They are still part of the network, but they will not be assigned to any virtual machine.

To do so, use the ‘onevnet hold’ and ‘onevnet release’ commands. By default, the address will be put on hold in all ARs containing it; if you need to hold the IP of a specific AR you can specified it with the ‘-a <AR_ID>’ option.

```bash
#Hold IP 10.0.0.120 in all ARs
$ onevnet hold "Private Network" 10.0.0.120

#Hold IP 10.0.0.123 in AR 0
$ onevnet hold 0 10.0.0.123 -a 0
```

You see the list of leases on hold with the ‘onevnet show’ command, they’ll show up as used by virtual machine -1, ‘V: -1’

3.2.5 Using a Virtual Network

Once the Virtual Networks are setup, they can be made available to users based on access rights and ownership. The preferred way to do so is through **Virtual Data Center abstraction**. By default, all Virtual Networks are automatically available to the group users.

Virtual Network can be used by VMs in two different ways:
• Manual selection: NICs in the VMs are attached to a specific Virtual Network.
• Automatic selection: Virtual networks are scheduled like other resources needed by the VM (like hosts or datastores).

**Manual Attach a Virtual Machine to a Virtual Network**

To attach a Virtual Machine to a Virtual Network simply specify its name or ID in the NIC attribute. For example, to define VM with a network interface connected to the Private Virtual Network just include in the template:

```plaintext
NIC = [ NETWORK = "Private" ]
```

Equivalently you can use the network ID as:

```plaintext
NIC = [ NETWORK_ID = 0 ]
```

The Virtual Machine will also get a free address from any of the address ranges of the network. You can also request a specific address just by adding the IP or MAC to NIC. For example to put a Virtual Machine in the network Private and request 10.0.0.153 use:

```plaintext
NIC = [ NETWORK = "Network", IP = 10.0.0.153 ]
```

**Warning:** Note that if OpenNebula is not able to obtain a lease from a network the submission will fail.

**Warning:** Users can only attach VMs or make reservations from Virtual Networks with USE rights on it. See the [Managing Permissions documentation](#) for more information.

**Automatic Attach a Virtual Machine to a Virtual Network**

You can delay the network selection for each NIC in the VM to the deployment phase. In this case the Scheduler will pick the Virtual Network among the available networks in the host selected to deploy the VM.

This strategy is useful to prepare generic VM templates that can be deployed in multiple OpenNebula clusters.

To set the automatic selection mode, simply add the attribute `NETWORK_MODE = "auto"` into the NIC attribute.

```plaintext
NIC = [ NETWORK_MODE = "auto" ]
```

Also you can add `SCHED_REQUIREMENTS` and `SCHED_RANK` when this mode is activated. This will let you specify which networks can be used for a specific NIC (`SCHED_REQUIREMENTS`) and what are your preferences (`SCHED_RANK`) to select a network among the suitable ones.

```plaintext
NIC = [ NETWORK_MODE = "auto",
       SCHED_REQUIREMENTS = "TRAFFIC_TYPE = "public" & INBOUND_AVG_BW<1500",
       SCHED_RANK = "-USED_LEASES" ]
```

In this case the scheduler will look for any Virtual Network in the selected cluster with a custom tag `TRAFFIC_TYPE` to be equal to `public` and `INBOUND_AVG_BW` less than 1500. Among all the networks that satisfy these requirements the scheduler will select that with most free leases.
Attach a Virtual Machine to a NIC Alias

To attach a NIC alias to a VM you need to refer the parent NIC by its NAME attribute:

```
NIC = [ NETWORK = "public", NAME = "test" ]
```

Then you can attach an alias using a NIC_ALIAS attribute:

```
NIC_ALIAS = [ NETWORK = "private", PARENT = "test" ]
```

If the nic NAME is empty, it will be generated automatically in the form NIC${NIC_ID}. This name can be also used to create an alias, e.g. NIC_ALIAS = [ NETWORK = "private", PARENT = "NIC0" ]

**Note:** You can also use the onerem command using the option --alias alias so that NIC will be attached as an alias, instead of as a NIC.

**Important:** Any attribute supported by a NIC attribute can be also used in an alias except for NETWORK_MODE. A NIC_ALIAS network cannot be automatically selected.

Configuring the Virtual Machine Network

Hypervisors will set the MAC address for the NIC of the Virtual Machines, but not the IP address. The IP configuration inside the guest is performed by the contextualization process, check the contextualization guide to learn how to prepare your Virtual Machines to automatically configure the network

**Note:** Alternatively a custom external service can configure the Virtual Machine network (e.g. your own DHCP server in a separate virtual machine)

3.2.6 NSX Specific

This section describes how to create a vnet in OpenNebula that reference a logical switch in NSX-V or NSX-T.

**Warning:** NSX_STATUS must be OK before a logical switch created, imported or deleted.

Creating a new logical switch

Creating a new logical switch means, create a vnet in OpenNebula and a logical switch in NSX Manager at the same time. Once the logical switch is created in NSX, OpenNebula will update its vnet attributes to reference to the created logical switch

Creating from Sunstone

- In Sunstone go to:
  Network > Virtual Networks > Create
• In the General tab type:
  – Name: Logical switch name
  – Description: Logical Switch Description
  – Cluster: Select the appropriate cluster

• In the Conf tab select “NSX”
• Select OpenNebula Host
• Select the Transport Zone
• Select the rest of attributes and click on “Addresses”
• Type an address range
• And click on create, and the network will be created.
• To check that the network was imported correctly, the next attributes should have values
  – VCENTER_NET_REF: network id on vcenter
  – VCENTER_PORTGROUP_TYPE: “Opaque Network” or “Distributed Port Group”
  – NSX_ID: network id on NSX
• And you can also verify into NSX, there is a network with the same id and the same name.
  – For NSX-V, open vcenter server and go to:
    Network & Security > Logical Switches
  – For NSX-T open NSX Manager and go to:
    Advanced Networking & Security > Switching > Switches
3.2. Virtual Networks
3.2. Virtual Networks
3.2. Virtual Networks

Create Virtual Network

- IPv4
- IPv4/6
- IPv6
- Ethernet

First IPv4 address: 192.168.1.1
Size: 255

Virtual Networks

- logical_switch_test01
- Owner: onadmin
- Group: onadmin
- Reservation: No
- Cluster: 0
- Leases: 0/255

Virtual Network created
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Creating from CLI

You can create a NSX network through onevnet command. First you need a network template, here is examples for both NSX-T and NSX-V:

Example template for NSX-T:

File: nsxt_vnet.tmpl

```plaintext
NAME="logical_switch_test01"
DESCRIPTION="NSX Logical Switch created from OpenNebula CLI"
BRIDGE="logical_switch_test01"
BRIDGE_TYPE="vcenter_port_groups"
VCENTER_INSTANCE_ID=<vcenter_instance_id of the host>
VCENTER_ONE_HOST_ID=<id of the host>
VCENTER_PORTGROUP_TYPE="Opaque Network"
VN_MAD="vcenter"
NSX_TZ_ID=<id of the transport zone>
AR = [ TYPE="ETHER", SIZE=255 ]
```

Example template for NSX-V:

File: nsxv_vnet.tmpl

```plaintext
NAME="logical_switch_test01"
DESCRIPTION="NSX Logical Switch created from OpenNebula CLI"
BRIDGE="logical_switch_test01"
BRIDGE_TYPE="vcenter_port_groups"
VCENTER_INSTANCE_ID=<vcenter_instance_id of the host>
VCENTER_ONE_HOST_ID=<id of the host>
VCENTER_PORTGROUP_TYPE="NSX-V"
VN_MAD="vcenter"
NSX_TZ_ID=<id of the transport zone>
AR = [ TYPE="ETHER", SIZE=255 ]
```

Once you have your vnet template file you can run the command:

```
onevnet create <file vnet template>
```

After create the network you can follow the steps defined above to check that the vnet was created successfully.

Importing existing logical switches

This section describes how to import logical switches, for both NSX-T and NSX-V. The procedure is the same as other vcenter networks.

In the list of available networks to import, it will only show NSX-V and NSX-T (Opaque networks) if NSX_STATUS = OK.
In any case, all NSX networks (represented in vCenter) can be listed without having the host attribute NSX_STATUS = OK using the following CLI command:

```bash
onevcenter list_all -o networks -h <host_id>
```

**Importing from Sunstone**

- To import a Logical Switch go to:
  - Network > Virtual Networks > Import

- Select the correct OpenNebula host and click “Get-Networks”

- Select the network you want to import and click on “Import”

- A message indicates that the network was imported
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3.2. Virtual Networks
3.2. Virtual Networks
• To check that the network was imported correctly, the next attributes should have values
  – VCENTER_NET_REF: network id on vcenter
  – VCENTER_PORTGROUP_TYPE: “Opaque Network” or “Distributed Port Group”
  – NSX_ID: network id on NSX

**Importing from CLI**

The import process from CLI is the same as others vcenter networks. For more details go to: import_network_onevcenter

**Deleting logical switches**

The process of deleting a logical switch is the same as others vnets.

**Attaching logical switches to VMs**

The process of attaching a logical switch to a VM is the same as others vnets.

**Detaching logical switches to VMs**

The process of detaching a logical switch to a VM is the same as others vnets.

**Limitations**

At this time not all attributes are available at creation time:
  • OpenNebula cannot create universal logical switches
  • OpenNebula cannot change IP discovery and MAC learning.

NSX-V creates a standard port group called “none” when creating an EDGE or DLR. This network has no host attached so OpenNebula will not be able to import it.

### 3.3 Virtual Routers

Virtual Routers provide routing across Virtual Networks. The administrators can easily connect Virtual Networks from Sunstone and the CLI. The routing itself is implemented with a Virtual Machine appliance available though the market place. This Virtual Machine can be seamlessly deployed in high availability mode.

#### 3.3.1 Download the Virtual Router Appliance

OpenNebula provides a light weight Alpine-based virtual router. The virtual router image is prepared to run in a HA mode, and process the context information from OpenNebula. So its base capabilities can be easily extended.
  • Download the appliance from the market place. For example to put the virtual router image in the default datastore and create a Virtual Router template named vrouter_alpine use:
3.3.2 Creating a new Virtual Router

New Virtual Routers are created from a special type of VM Template, as the one created automatically when downloading the market app.

Sunstone

To create a new Virtual Router from Sunstone, follow the wizard to select the Virtual Networks that will get logically linked to it. This connection takes effect when the Virtual Machine containing the VR Appliance is automatically deployed, with a network interface attached to each Virtual Network.

For each Virtual Network, the following options can be defined:

- **Floating IP.** Only used in High Availability, explained below.
- **Force IPv4.** You can force the IP assigned to the network interface. When the VR is not configured in High Availability, this will be the IP requested for the Virtual Machine appliance.
- **Management interface.** If checked, this network interface will be a Virtual Router management interface. Traffic will not be forwarded to it.

Once ready, click the “create” button to finish. OpenNebula will create the Virtual Router and the Virtual Machines automatically.
Virtual Routers can be managed with the `onevrouter` command.

To create a new Virtual Router from the CLI, first you need to create a VR Template file, with the following attributes:

Then use the `onevrouter create` command:

```bash
$ cat myvr.txt
NAME = my-vr
NIC = [ 
   NETWORK="blue-net",
   IP="192.168.30.5"
] 
NIC = [ 
   NETWORK="red-net"
]

$ onevrouter create myvr.txt
ID: 1
```

At this point the Virtual Router resource is created, but it does not have any Virtual Machines. A second step is needed to create one (or more, if High Availability is used):

```bash
$ onevrouter instantiate <vrouterid> <templateid>
```

### 3.3.3 Managing Virtual Routers

Using the Virtual Routers tab in Sunstone, or the `onevrouter show` command, you can retrieve the generic resource information such as owner and group, the list of Virtual Networks interconnected by this router, and the Virtual...
Machines that are actually providing the routing.

The Virtual Networks connected to the VR machines can be modified with the attach/detach actions. In Sunstone the actions can be found in the Virtual Router’s main information panel, in the networks table. The options to add a new Virtual Network are the same that were explained for the creation wizard, see previous section.

The `onevrouter nic-attach` command takes a file containing a single NIC attribute. Alternatively, you can provide the new virtual network settings with command options, see `onevrouter nic-attach -h` for more information.

After a NIC is attached or detached, the Virtual Machine appliances are automatically reconfigured to start routing to the new interface. No other action, like a reboot, is required.

Managing Virtual Router VMs

The Virtual Machines that are associated to a Virtual Router have all actions allow except nic-attach/dettach. They can be terminated and new Virtual Machines can be added to an existing Virtual Router.

All the Virtual Machines associated with a Virtual Router are terminated automatically when the Virtual Router is deleted. Each VM can however be terminated individually at any time.

To create new VMs use the `onevrouter instantiate` command, or the “Instantiate VMs” dialog in Sunstone.
### 3.3.4 High Availability

More than one Virtual Machines can be associated to a Virtual Router in order to implement a high availability scenario. In this case, OpenNebula will also assign a floating IP to the group of Virtual Machines, that will coordinate to manage the traffic directed to that IP.

To enable a high availability scenario, you need to choose 2 or more number of instances when the Virtual Router is created in Sunstone. In the CLI, the number of VM instances is given with the \(-m\) option.

```
$ onevrouter instantiate -h
[...]
-m, --multiple x Instance multiple VMs
```

In this scenario, the following Virtual Router options became relevant:

- **Keepalived ID**: Optional. Sets keepalived configuration parameter `virtual_router_id`.
- **Keepalived password**: Optional. Sets keepalived configuration parameter `authentication/auth_pass`.

And for each Virtual Network Interface:

- **Floating IP**: Check it to enable the floating IP.
- **Force IPv4**: Optional. With the floating IP option selected, this field requests a fixed IP for that floating IP, not the individual VM IPs.

The floating IP assignment is managed in a similar way to normal VM IPs. If you open the information of the Virtual Network, it will contain a lease assigned to the Virtual Router (not a VM). Besides the floating IP, each VM will get their own individual IP.

Other Virtual Machines in the network will use the floating IP to contact the Virtual Router VMs. At any given time, only one VM is using that floating IP address. If the active VM crashes, the other VMs will coordinate to assign the floating IP to a new Virtual Router VM.

### 3.3.5 Customization

You can provide two optional parameters in the context to configure the keepalived service started in the Virtual Router VM:

- **VROUTER_KEEPALIVED_PASSWORD**: Password used for the service to protect the service from packages of rogue machines. By default the service is configured without password.
- **VROUTER_KEEPALIVED_ID**: Number identifier of the service (0-255). This is useful when you have several virtual routers or other keepalived services in the same network. By default it is generated from the Virtual Router ID (\$(vrouter_id & 255)) but you can specify it manually if needed.

These parameters can also be provided in the Virtual Router creation wizard of Sunstone.

### 3.4 Security Groups

Security Groups define firewall rules to be applied on Virtual Machines.

**Warning**: Security groups is not supported for OpenvSwitch and vCenter networks.
3.4.1 Defining a Security Group

A Security Group is composed of several Rules. Each Rule is defined with the following attributes:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Type</th>
<th>Meaning</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROTOCOL</td>
<td>Manda-</td>
<td>Defines the protocol of the rule</td>
<td>ALL, TCP, UDP, ICMP, IPSEC</td>
</tr>
<tr>
<td>RULE_TYPE</td>
<td>Manda-</td>
<td>Defines the direction of the rule</td>
<td>INBOUND, OUTBOUND</td>
</tr>
<tr>
<td>IP</td>
<td>Option</td>
<td>If the rule only applies to a specific net.</td>
<td>A valid IP</td>
</tr>
<tr>
<td>SIZE</td>
<td>Option</td>
<td>If the rule only applies to a net. The number of total consecutive IPs of the network. Use always with IP.</td>
<td>An integer &gt;= 1</td>
</tr>
<tr>
<td>RANGE</td>
<td>Option</td>
<td>A Port Range to filter specific ports. Only works with TCP and UDP.</td>
<td>(iptables syntax) multiple ports or port ranges are separated using a comma, and a port range is specified using a colon. Example: 22,53,80:90,110,1024:65535</td>
</tr>
<tr>
<td>ICMP_TYPE</td>
<td>Option</td>
<td>Specific ICMP type of the rule. If a type has multiple codes, it includes all the codes within. This can only be used with ICMP. If omitted the rule will affect the whole ICMP protocol.</td>
<td>0,3,4,5,8,9,10,11,12,13,14,17,18</td>
</tr>
<tr>
<td>NETWORK_ID</td>
<td>Option</td>
<td>Specify a network ID to which this Security Group will apply</td>
<td>A valid networkd ID</td>
</tr>
</tbody>
</table>

To create a Security Group, use the Sunstone web interface, or create a template file following this example:

```bash
$ cat ./sg.txt

NAME = test

RULE = [
    PROTOCOL = TCP,
    RULE_TYPE = inbound,
    RANGE = 1000:2000
]

RULE = [
    PROTOCOL = TCP,
    RULE_TYPE = outbound,
    RANGE = 1000:2000
]

RULE = [
    PROTOCOL = ICMP,
    RULE_TYPE = inbound,
    NETWORK_ID = 0
]

$ onesecgroup create ./sg.txt
ID: 102
```
.. note:: This guide focuses on the CLI command ``onesecgroup``, but you can also manage Security Groups using :ref:`Sunstone <sunstone>`, mainly through the Security Group tab in a user friendly way.

3.4.2 Using a Security Group

To apply a Security Group to your Virtual Machines, you can assign them to the Virtual Networks. Either use the Sunstone wizard, or set the SECURITY_GROUPS attribute:

```
$ onevnet update 0
SECURITY_GROUPS = "100, 102, 110"
```

When a Virtual Machine is instantiated, the rules are copied to the VM resource and can be seen in the CLI and Sunstone.
Advanced Usage

To accommodate more complex scenarios, you can also set Security Groups to each Address Range of a Virtual Network.

```shell
$ onevnet updatear 0 1
SECURITY_GROUPS = "100, 102, 110"
```

Moreover, each Virtual Machine Template NIC can define a list of Security Groups:

```plaintext
NIC = [{
  NETWORK = "private-net",
  NETWORK_UNAME = "oneadmin",
  SECURITY_GROUPS = "103, 125"
}]
```

If the Address Range or the Template NIC defines SECURITY_GROUPS, the IDs will be added to the ones defined in the Virtual Network. All the Security Group IDs are combined, and applied to the Virtual Machine instance.

### 3.4.3 The Default Security Group

There is a special Security Group: default (ID 0). This security group allows all OUTBOUND traffic and all INBOUND traffic.

Whenever a network is created, the default Security Group is added to the network.
This means you must edit every newly created network and remove the default Security Group from it. Otherwise even if you add other Security Groups, the default one will allow all traffic and therefore override the rest of the Security Groups.

**Note for administrators:** you may want to remove the rules included in the default security groups. This way users are forced to create security groups (otherwise they will not have connectivity to and from the VMs) which avoid some security problems.

### 3.4.4 Security Group Update

Security Groups can be updated to edit or add new rules. These changes are propagated to all VMs in the security group, so it may take some time till the changes are applied. The particular status of a VM can be checked in the security group properties, where outdated and up-to-date VMs are listed.

If the update process needs to be reset, i.e. apply again the rules, you can use the `onesecgroup commit` command.

### 3.5 Virtual Networks Templates

The Virtual Network Templates allows the end user to create virtual networks without knowing the details of the underlying infrastructure. Typically the administrator sets the templates up with the required physical attributes, e.g. driver or physical device information and let the end user to add all the logic information like address ranges or gateway.

Virtual Network Templates can be instantiated several times and shared between multiple users.

#### 3.5.1 Virtual Network Template Definition

A Virtual Network Template is a representation of a Virtual Network, so a template can be defined by using the same attributes available for a Virtual Network. Virtual Network Templates and Virtual Networks also share their required attributes depending on driver they are using (see the requirements [here](#), Physical Network Attributes section).

When a network is created by instantiating a Virtual Network Template is is associated to the default cluster. You can control which clusters the networks will be in with the `CLUSTER_IDS` attribute.

Here is an example of a Virtual Network Template with one address range:

```
NAME=vntemplate
VN_MAD="bridge"
AR=[
    IP="10.0.0.1",
    SIZE="10",
    TYPE="IP4"
]
CLUSTER_IDS="1,100"
```

The networks created by instantiating this template will be on clusters 1 and 100.

#### 3.5.2 Using Virtual Network Templates

By default just one admin can create Virtual Network Templates, if other users need permissions for creating Virtual Network Templates it can be provided by creating a specific ACL.

Once the Virtual Network Template is created the access to it can be managed by its permissions. For example, if a user needs to instantiate an specific template, it would be enough to give the template `USE` permission for others. You can find more information about permissions [here](#).
Operations

The available operations for Virtual Network Templates are the following:

- allocate
- instantiate
- info
- update
- delete
- chown
- chmod
- clone
- rename
- lock
- unlock

3.5.3 Preparing Virtual Network Templates for End-Users

First of all, as oneadmin user (or any other user who have CREATE permissions for Virtual Network Templates), create a Virtual Network Template and set all the attributes which need to be fixed at the template like bridge, vlan id, etc.

Note: Note that virtual network restricted attributes will be also restricted for virtual network templates.

```
$ cat vn_template.txt
NAME=vntemplate
VN_MAD="bridge"
BRIDGE="virbr0"
$ onevntemplate create vn_template.txt
ID: 0
```

Once the Virtual Network Template has been created, change the permissions to make it available for the users you want. In the example below all the users will be able to instantiate the template:

```
$ onevntemplate chmod 0 604
$ onevntemplate show 0
TEMPLATE 0 INFORMATION
ID : 0
NAME : vntemplate
USER : oneadmin
GROUP : oneadmin
LOCK : None
REGISTER TIME : 11/28 14:44:21
PERMISSIONS
OWNER : um-
GROUP : ---
OTHER : u--
TEMPLATE CONTENTS
```

3.5. Virtual Networks Templates
The network is now ready, users can create VMs and attach their interfaces to the newly created Virtual Network. Simply adding \texttt{NIC = [ NETWORK = private ]} or selecting it through Sunstone.

\textbf{Note:} Note that for using the newly created Virtual Network, the user needs to define an Address Range either during the Virtual Network Template instantiation or just updating the Virtual Network.

### 3.6 Virtual Network Self-Provisioning

End-users can create their own virtual networks in two different ways: making a reservation or instantiating a Virtual Network Template.

#### 3.6.1 Reservations

Reservations allows users to create their own networks consisting of portions of an existing Virtual Network. Each portion is called a Reservation. To implement this you need to:

- **Define a VNET**, with the desired ARs and configuration attributes. These attributes will be inherited by any Reservation, so the final users do not need to deal with low-level networking details.

- **Setting up access**. In order to make a Reservation, users needs USE rights on the Virtual Network, just as if they would use it to directly to provision IPs from it.

- **Make Reservations**. Users can easily request specific addresses or just a number of addresses from a network. Reservations are placed in a new Virtual Network for the user.

- **Use Reservations**. Reservations are Virtual Networks and offer the same interface, so simply point any Virtual Machine to them. The number of addresses and usage stats are shown also in the same way.

**Make and delete Reservations**

To make a reservations just choose the source Virtual Network, the number of addresses and the name of the reservation. For example to reserve 10 addresses from Private and place it on MyVNET just:

\begin{verbatim}
$ onevnet reserve Private -n MyVNET -s 10
Reservation VNET ID: 7
\end{verbatim}

As a result a new VNET has been created:

\begin{verbatim}
$ onevnet list
\end{verbatim}

<table>
<thead>
<tr>
<th>ID</th>
<th>USER</th>
<th>GROUP</th>
<th>NAME</th>
<th>CLUSTER</th>
<th>BRIDGE</th>
<th>LEASES</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>admin</td>
<td>oneadmin</td>
<td>Private</td>
<td>-</td>
<td>vbr1</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>helen</td>
<td>users</td>
<td>MyVNET</td>
<td>-</td>
<td>vbr1</td>
<td>0</td>
</tr>
</tbody>
</table>
Note that Private shows 10 address leases in use, those reserved by Virtual Network 7. Also note that both networks share the same configuration, e.g. BRIDGE.

Reservations can include advanced options such as:

- The AR where you want to make the reservation from in the source Virtual Network
- The starting IP or MAC to make the reservation from

A reservation can be remove just as a regular Virtual Network:

```
$ onenet delete MyVNET
```

### Using Reservations

To use a reservation you can use it as any other Virtual Network; as they expose the same interface. For example, to attach a virtual machine to the previous Reservation:

```
NIC = [ NETWORK = "MyVNET"]
```

### Updating Reservations

A Reservation can be also extended with new addresses. This is, you can add a new reservation to an existing one. This way a user can refer to its own network with a controlled and deterministic address space.

---

**Note:** Reservation increase leases counters on the user and group, and they can be limited through a quota.

**Note:** The reservation interface is exposed by Sunstone in a very convenient way.

### 3.6.2 Virtual Network Templates

Virtual Network Templates allow end users to create their own network without knowledge of the underlying infrastructure. Virtual Network Templates, unlike Reservations, allows end user to set the logic attributes, like address ranges, dns server or gateway of the network. See the Virtual Network Templates guide for more information.
CHAPTER FOUR

VIRTUAL MACHINE MANAGEMENT

4.1 Overview

This chapter contains documentation on how to create and manage Virtual Machine templates, instances, and Images (VM disks).

4.1.1 How Should I Read This Chapter

Before reading this chapter, you should have already installed your Frontend, the KVM Hosts, LXD Hosts or vCenter node and have an OpenNebula cloud up and running with at least one virtualization node.

For vCenter based infrastructures read first the vCenter Specifics Section.

4.1.2 Hypervisor Compatibility

<table>
<thead>
<tr>
<th>Section</th>
<th>Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual Machine Images</td>
<td>This Section applies to all Hypervisors.</td>
</tr>
<tr>
<td>Virtual Machine Templates</td>
<td>This Section applies to all Hypervisors.</td>
</tr>
<tr>
<td>Virtual Machine Instances</td>
<td>This Section applies to all Hypervisors.</td>
</tr>
<tr>
<td>vCenter Specifics</td>
<td>This Section applies to vCenter.</td>
</tr>
</tbody>
</table>

4.2 Managing Images

The Storage system allows OpenNebula administrators and users to set up Images, which can be operative systems or data, to be used in Virtual Machines easily. These Images can be used by several Virtual Machines simultaneously, and also shared with other users.

If you want to customize the Storage in your system, visit the Storage subsystem documentation.

4.2.1 Image Types

There are six different types of Images. Using the command `oneimage chtype`, you can change the type of an existing Image.

For Virtual Machine disks:

- OS: An bootable disk Image. Every VM template must define one DISK referring to an Image of this type.
• **CDROM**: These Images are read-only data. Only one Image of this type can be used in each *VM template*.

• **DATABLOCK**: A datablock Image is a storage for data. These Images can be created from previous existing data, or as an empty drive.

“File” types. Images of these types cannot be used as VM disks, and are listed in Sunstone under the Files tab:

• **KERNEL**: A plain file to be used as kernel (VM attribute OS/KERNEL_DS).

• **RAMDISK**: A plain file to be used as ramdisk (VM attribute OS/INITRD_DS).

• **CONTEXT**: A plain file to be included in the context CD-ROM (VM attribute CONTEXT/FILES_DS).

---

**Note**: KERNEL, RAMDISK and CONTEXT file Images can be registered only in File Datastores.

---

**Note**: Some of the operations described below do not apply to KERNEL, RAMDISK and CONTEXT Images, in particular: clone and persistent.

---

### 4.2.2 Image Life-cycle

<table>
<thead>
<tr>
<th>Short state</th>
<th>State</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>lock</td>
<td>LOCKED</td>
<td>The Image file is being copied or created in the Datastore.</td>
</tr>
<tr>
<td>lock</td>
<td>LOCKED_USED</td>
<td>Image file is being copied or created in the Datastore, with VMs waiting for the operation to finish.</td>
</tr>
<tr>
<td>lock</td>
<td>LOCKED_USED_PERS</td>
<td>Same as LOCKED_USED, for Persistent Images</td>
</tr>
<tr>
<td>rdy</td>
<td>READY</td>
<td>Image ready to be used.</td>
</tr>
<tr>
<td>used</td>
<td>USED</td>
<td>Non-persistent Image used by at least one VM. It can still be used by other VMs.</td>
</tr>
<tr>
<td>used</td>
<td>USED_PERS</td>
<td>Persistent Image is use by a VM. It cannot be used by new VMs.</td>
</tr>
<tr>
<td>disa</td>
<td>DISABLED</td>
<td>Image disabled by the owner, it cannot be used by new VMs.</td>
</tr>
<tr>
<td>err</td>
<td>ERROR</td>
<td>Error state, a FS operation failed. See the Image information with oneimage show for an error message.</td>
</tr>
<tr>
<td>dele</td>
<td>DELETE</td>
<td>The Image is being deleted from the Datastore.</td>
</tr>
<tr>
<td>clon</td>
<td>CLONE</td>
<td>The Image is being cloned.</td>
</tr>
</tbody>
</table>

This is the state diagram for **persistent** Images:
And the following one is the state diagram for **non-persistent** Images:
4.2.3 Managing Images

Users can manage their Images using the command line interface command `oneimage`. The complete reference is [here](#).

You can also manage your Images using Sunstone, selecting the Images tab. By default this tab is available in the `admin` view, but not in the `cloud` or `groupadmin` views.

**Create Images**

The three types of Images can be created from an existing file, but for `datablock` Images you can specify a size and let OpenNebula create an empty Image in the Datastore.
If you want to create an **OS Image**, you need to prepare a contextualized virtual machine, and extract its disk.

Please read first the documentation about **VM contextualization here**.

Once you have a disk you want to register, you can upload it directly using Sunstone:

![Image](create_image.png)

To register it from the command line you need to create a new **image template**, and submit it using the `oneimage create` command.

The complete reference for the image template is here. This is how a sample template looks like:

```bash
$ cat ubuntu_img.one
NAME = "Ubuntu"
PATH = "/home/cloud/images/ubuntu-desktop/disk.0"
TYPE = "OS"
DESCRIPTION = "Ubuntu desktop for students."
```

You need to choose the Datastore where to register the new Image. To know the available datastores, use the `onedatastore list` command. In a clean installation you will only have one datastore with type `img`, default.

```bash
$ onedatastore list
ID NAME SIZE AVAIL CLUSTERS IMAGES TYPE DS TM STAT
0 system 145.2G 56% 0 0 sys - shared on
1 default 145.2G 56% 0 3 img fs shared on
2 files 145.2G 56% 0 0 fil fs ssh on
```

To submit the template, you just have to issue the command

```bash
$ oneimage create ubuntu_img.one --datastore default
ID: 0
```

### 4.2. Managing Images
You can also create Images using just parameters in the `oneimage create` call. The parameters to generate the Image are as follows:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>--name name</code></td>
<td>Name of the new Image</td>
</tr>
<tr>
<td><code>--description description</code></td>
<td>Description for the new Image</td>
</tr>
<tr>
<td><code>--type type</code></td>
<td>Type of the new Image: OS, CDROM, DATABLOCK, KERNEL, RAMDISK, CONTEXT</td>
</tr>
<tr>
<td><code>--persistent</code></td>
<td>Tells if the Image will be persistent</td>
</tr>
<tr>
<td><code>--prefix prefix</code></td>
<td>Device prefix for the disk (e.g. hd, sd, xvd or vd)</td>
</tr>
<tr>
<td><code>--target target</code></td>
<td>Device the disk will be attached to</td>
</tr>
<tr>
<td><code>--path path</code></td>
<td>Path of the Image file</td>
</tr>
<tr>
<td><code>--driver driver</code></td>
<td>Driver to use (raw, qcow2, tap:aio:...)</td>
</tr>
<tr>
<td><code>--disk_type disk_type</code></td>
<td>Type of the Image (BLOCK, CDROM or FILE)</td>
</tr>
<tr>
<td><code>--source source</code></td>
<td>Source to be used. Useful for not file-based Images</td>
</tr>
<tr>
<td><code>--size size</code></td>
<td>Size in MB. Used for DATABLOCK type</td>
</tr>
</tbody>
</table>

To create the previous example Image you can do it like this:

```bash
$ oneimage create --datastore default --name Ubuntu --path /home/cloud/images/ubuntu-desktop/disk.0
--description "Ubuntu desktop for students."
```

**Note:** You can use `gz` compressed image files when registering them in OpenNebula.

### Limitations when Uploading Images from Sunstone

Image file upload to the server via the client browser is possible. The process is as follow:

- **Step 1:** The client uploads the whole image file to the server in a temporal file in the `tmpdir` folder specified in the configuration.
- **Step 2:** OpenNebula registers an Image setting the PATH to that temporal file.
- **Step 3:** OpenNebula copies the image file to the datastore.
- **Step 4:** The temporal file is deleted and the request returns successfully to the user (a message pops up indicating that Image was uploaded correctly).

Note that when file sizes become big (normally over 1GB), and depending on your hardware, it may take long to complete the copying in step 3. Since the upload request needs to stay pending until copying is successful (so it can delete the temp file safely), there might be Ajax timeouts and/or lack of response from the server. This may cause errors, or trigger re-uploads (which re-initiate the loading progress bar).

### Clone Images

Existing Images can be cloned to a new one. This is useful to make a backup of an Image before you modify it, or to get a private persistent copy of an Image shared by other user. Note that persistent Images with snapshots cannot be cloned. In order to do so, the user would need to flatten it first, see the `snapshots` section for more information.

To clone an Image, execute
To clone an image, you can use the following command:

```
$ oneimage clone Ubuntu new_image
```

You can optionally clone the Image to a different Datastore. The new Datastore must be compatible with the current one, i.e. have the same DS_MAD drivers.

```
$ oneimage clone Ubuntu new_image --datastore new_img_ds
```

The Sunstone Images tab also contains a dialog for the clone operation:

![Clone Image Dialog]

### Listing Available Images

You can use the `oneimage list` command to check the available images in the repository.

```
$ oneimage list
```

<table>
<thead>
<tr>
<th>ID</th>
<th>USER</th>
<th>GROUP</th>
<th>NAME</th>
<th>DATASTORE</th>
<th>SIZE</th>
<th>TYPE</th>
<th>PER</th>
<th>STAT</th>
<th>RVMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>oneadmin</td>
<td>oneadmin</td>
<td>ttylinux-vd</td>
<td>default</td>
<td>200M OS</td>
<td>OS</td>
<td>No used</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>johndoe</td>
<td>users</td>
<td>my-ubuntu-disk</td>
<td>default</td>
<td>200M OS</td>
<td>OS</td>
<td>Yes used</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>alice</td>
<td>testgroup</td>
<td>customized-ubuntu</td>
<td>default</td>
<td>200M OS</td>
<td>OS</td>
<td>Yes used</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

To get complete information about an Image, use `oneimage show`, or list Images continuously with `oneimage top`.

**Note:** Orphan images (i.e images not referenced by any template) can be shown with `oneimage orphans` command.
Sharing Images

The users can share their Images with other users in their group, or with all the users in OpenNebula. See the Managing Permissions documentation for more information.

Let’s see a quick example. To share the Image 0 with users in the group, the USE right bit for GROUP must be set with the chmod command:

```
$ oneimage show 0
...
PERMISSIONS
OWNER : um-
GROUP : ---
OTHER : ---

$ oneimage chmod 0 640

$ oneimage show 0
...
PERMISSIONS
OWNER : um-
GROUP : u--
OTHER : ---
```

The following command allows users in the same group USE and MANAGE the Image, and the rest of the users USE it:

```
$ oneimage chmod 0 664

$ oneimage show 0
...
PERMISSIONS
OWNER : um-
GROUP : um-
OTHER : u--
```

Making Images Persistent

Use the `oneimage persistent` and `oneimage nonpersistent` commands to make your Images persistent or not.

A persistent Image saves back to the datastore the changes made inside the VM after it is shut down.

```
$ oneimage list
ID USER GROUP NAME DATASTORE SIZE TYPE PER STAT RVMS
 0 oneadmin oneadmin Ubuntu default 10G OS No rdy 0

$ oneimage persistent Ubuntu

$ oneimage list
ID USER GROUP NAME DATASTORE SIZE TYPE PER STAT RVMS
 0 oneadmin oneadmin Ubuntu default 10G OS Yes rdy 0

$ oneimage list
ID USER GROUP NAME DATASTORE SIZE TYPE PER STAT RVMS
 0 oneadmin oneadmin Ubuntu default 10G OS No rdy 0

$ oneimage nonpersistent 0

$ oneimage list
ID USER GROUP NAME DATASTORE SIZE TYPE PER STAT RVMS
 0 oneadmin oneadmin Ubuntu default 10G OS No rdy 0
```

Note that persistent Images with snapshots cannot be made non-persistent. In order to do so, the user would need to flatten it first, see the snapshots section for more information.

4.2. Managing Images
Managing Snapshots in Persistent Images

Persistent Images can have associated snapshots if the user created them during the life-cycle of VM that used the persistent Image. The following are operations that allow the user to manage these snapshots directly:

- **oneimage snapshot-revert <image_id> <snapshot_id>**: The active state of the Image is over-written by the specified snapshot. Note that this operation discards any unsaved data of the disk state.
- **oneimage snapshot-delete <image_id> <snapshot_id>**: Deletes a snapshot. This operation is only allowed if the snapshot is not the active snapshot and if it has no children.
- **oneimage snapshot-flatten <image_id> <snapshot_id>**: This operation effectively converts the Image to an Image without snapshots. The saved disk state of the Image is the state of the specified snapshot. It’s an operation similar to running snapshot-revert and then deleting all the snapshots.

Images with snapshots cannot be cloned or made non-persistent. To run either of these operations the user would need to flatten the Image first.

4.2.4 How to Use Images in Virtual Machines

This is a simple example on how to specify Images as virtual machine disks. Please visit the virtual machine user guide and the virtual machine template documentation for a more thorough explanation.

Assuming you have an OS Image called Ubuntu desktop with ID 1, you can use it in your virtual machine template as a DISK. When this machine is deployed, the first disk will be taken from the Datastore.

Images can be referred in a DISK in two different ways:

- **IMAGE_ID**, using its ID as returned by the create operation
- **IMAGE**, using its name. In this case the name refers to one of the Images owned by the user (names can not be repeated for the same user). If you want to refer to an IMAGE of other user you can specify that with IMAGE_UID (by the uid of the user) or IMAGE_UNAME (by the name of the user).

```
CPU = 1
MEMORY = 3.08

DISK = [ IMAGE_ID = 7 ]
DISK = [ IMAGE = "Ubuntu",
        IMAGE_UNAME = "oneadmin" ]
DISK = [ type = swap,
        size = 1024 ]

NIC = [ NETWORK_ID = 1 ]
NIC = [ NETWORK_ID = 0 ]

# FEATURES=[ acpi="no" ]

GRAPHICS = [ type = "vnc",
             listen = "1.2.3.4",
             port = "5902" ]
```

Save Changes

Once the VM is deployed and changes are made to its disk, you can save those changes in two different ways:
• **Disk snapshots**, a snapshot of the disk state is saved, you can later revert to this saved state.

• **Disk save_as**, the disk is copied to a new Image in the datastore. A new virtual machine can be started from it. The disk must be in a consistent state during the save_as operation (e.g. by unmounting the disk from the VM).

A detailed description of this process is described in section *Virtual Machine Instances*.

### 4.2.5 How to Use File Images in Virtual Machines

**KERNEL and RAMDISK**

KERNEL and RAMDISK type Images can be used in the OS/KERNEL_DS and OS/INITRD_DS attributes of the VM template. See the *complete reference* for more information.

Example:

```plaintext
OS = [ KERNEL_DS = "$FILE[IMAGE=kernel3.6]", 
      INITRD_DS = "$FILE[IMAGE_ID=23]", 
      ROOT = "sda1", 
      KERNEL_CMD = "ro console=tty1" ]
```

**CONTEXT**

The *contextualization cdrom* can include CONTEXT type Images. Visit the *complete reference* for more information.

```plaintext
CONTEXT = [ 
            FILES_DS = "$FILE[IMAGE_ID=34] $FILE[IMAGE=kernel]"
            ]
```

### 4.3 Managing Virtual Machine Templates

In OpenNebula the Virtual Machines are defined with VM Templates. This section explains how to describe the wanted-to-be-ran Virtual Machine, and how users typically interact with the system.

The VM Template Pool allows OpenNebula administrators and users to register Virtual Machine definitions in the system, to be instantiated later as Virtual Machine instances. These Templates can be instantiated several times, and also shared with other users.

#### 4.3.1 Defining a VM

A Virtual Machine within the OpenNebula system consists of:

- A capacity in terms memory and CPU
- A set of NICs attached to one or more virtual networks
- A set of disk images
- Optional attributes like VNC graphics, the booting order, context information, etc.

Virtual Machines are defined in an OpenNebula Template. Templates are stored in the system to easily browse and instantiate VMs from them.
### Capacity & Name

#### Disks

Each disk is defined with a DISK attribute. A VM can use three types of disk:

- **Use a persistent Image**: changes to the disk image will persist after the VM is terminated.
- **Use a non-persistent Image**: a copy of the source Image is used, changes made to the VM disk will be lost.
- **Volatile**: disks are created on the fly on the target host. After the VM is terminated the disk is disposed.
Network Interfaces

Network interfaces can be defined in two different ways:

- **Manual selection**: interfaces are attached to a pre-selected Virtual Network. Note that this may require to build multiple templates considering the available networks in each cluster.

- **Automatic selection**: Virtual networks will be scheduled like other resources needed by the VM (like hosts or datastores). This way, you can hint the type of network the VM will need and it will be automatically selected among those available in the cluster. *See more details here.*
Network Interfaces Alias

Network interface alias allows you to have more than one IP on each network interface. This does not create a new virtual interface on the VM. The alias address is added to the network interface. An alias can be attached and detached. Note also that when a nic with an alias is detached, all the associated aliases are also detached.

The alias takes a lease from the network which it belongs to. So, for the OpenNebula it is the same as a NIC and exposes the same management interface, it is just different in terms of the associated virtual network interface within the VM.

**Note:** The network of the alias can be different from the network of the nic which is alias of.

Example

The following example shows a VM Template file with a couple of disks and a network interface, also a VNC section and an alias were added.

```
NAME = test-vm
MEMORY = 128
CPU = 1

DISK = [ IMAGE = "Arch Linux" ]
DISK = [ TYPE = swap,
        SIZE = 1024 ]

NIC = [ NETWORK = "Public", NETWORK_UNAME="oneadmin" ]
NIC = [ NETWORK = "Private", NAME = "private_net" ]
NIC_ALIAS = [ NETWORK = "Public", PARENT = "private_net" ]

GRAPHICS = [
```
Note: Check the VM definition file for a complete reference

Simple templates can be also created using the command line instead of creating a template file. For example, a similar template as the previous example can be created with the following command:

```
$ onetemplate create --name test-vm --memory 128 --cpu 1 --disk "Arch Linux" --nic --Public
```

For a complete reference of all the available options for onetemplate create, go to the CLI reference, or run onetemplate create -h.

Note: OpenNebula Templates are designed to be hypervisor-agnostic, but there are additional attributes that are supported for each hypervisor. Check the KVM configuration and vCenter configuration for more details.

### Other (Custom Tags)

This section in the Other tab is for all fields that haven’t any gap in the others tabs. You can introduce others own fields into this section, this values will be saved in the resource template. Also you can create a value of object type.

#### 4.3.2 Preparing Templates for End-Users

Besides the basic VM definition attributes, you can setup extra options in your VM Template.

**Customizable Capacity**

The capacity attributes (CPU, MEMORY, VCPU) can be modified each time a VM Template is instantiated. The Template owner can decide if and how each attribute can be customized.
The modification options available in the drop-down are:

- **fixed**: The value cannot be modified.
- **any value**: The value can be changed to any number by the user instantiating the Template.
- **range**: Users will be offered a range slider between the given minimum and maximum values.
- **list**: Users will be offered a drop-down menu to select one of the given options.
- **list-multiple**: Users will be offered a drop-down menu to select multiple of the given options.

If you are using a template file instead of Sunstone, the modification is defined with user input attributes (see below).

The absence of user input is an implicit “any value”. For example:

```plaintext
CPU = "1"
MEMORY = "2048"
VCPUs = "2"
USER_INPUTS = [
    CPU = "M\|list\|\|0.5,1,2,4\|1",
    MEMORY = "M\|range\|\|512..8192\|2048"
]
```

**Note:** Use float types for CPU, and integer types for MEMORY and VCPUs. More information in the Template reference documentation.

**Note:** This capacity customization can be forced to be disabled for any Template in the cloud view. Read more in the Cloud View Customization documentation.
Ask for User Inputs

The User Inputs functionality provides the Template creator the possibility to dynamically ask the user instantiating the Template dynamic values that must be defined.

A user input can be one of the following types:

- **text**: any text value.
- **password**: any text value. The interface will block the input visually, but the value will be stored as plain text.
- **text64**: will be encoded in base64 before the value is passed to the VM.
- **number**: any integer number.
- **number-float**: any number.
- **range**: any integer number within the defined min..max range.
- **range-float**: any number within the defined min..max range.
- **list**: the user will select from a pre-defined list of values.
- **list-multiple**: the user will select one or more options from a predefined list of values.
These inputs will be presented to the user when the Template is instantiated. The VM guest needs to be *contextualized* to make use of the values provided by the user.

**Note:** If a VM Template with user inputs is used by a Service Template Role, the user will be also asked for these inputs when the Service is created.

**Scheduling Actions**

You can define Scheduled Actions when defining a Template and at *VM instantiation.*
Set a Cost

Each VM Template can have a cost per hour. This cost is set by CPU and MEMORY MB, to allow users to change the capacity and see the cost updated accordingly. VMs with a cost will appear in the showback reports.

See the template file syntax here.

Enable End User Features

There are a few features of the Cloud View that will work if you configure the Template to make use of them:

- Users will see the Template logo and description, something that is not so visible in the normal admin view.
- The Cloud View gives access to the VM’s VNC, but only if it is configured in the Template.
- End users can upload their public ssh key. This requires the VM guest to be contextualized, and the Template must have the ssh contextualization enabled.
Make the Images Non-Persistent

If a Template is meant to be consumed by end-users, its Images should not be persistent. A persistent Image can only be used by one VM simultaneously, and the next user will find the changes made by the previous user.

If the users need persistent storage, they can use the “instantiate to persistent” functionality.

Prepare the Network Interfaces

End-users can select the VM network interfaces when launching new VMs. You can create templates without any NIC, or set the default ones. If the template contains any NIC, users will still be able to remove them and select new ones.

Because users will add network interfaces, you need to define a default NIC model in case the VM guest needs a specific one (e.g. virtio for KVM). This can be done with the NIC_DEFAULT attribute, or through the Template wizard. Alternatively, you could change the default value for all VMs in the driver configuration file (see the KVM one for example).
This networking customization can be disabled for each Template. The users instantiating the Template will not be able to add, remove, or customize set NICs set by the Template owner.
Note: This networking customization can be forced to be disabled for any Template in the cloud view. Read more in the Cloud View Customization documentation.

4.3.3 Instantiating Templates

From Sunstone:
From the CLI: the `onetemplate instantiate` command accepts a Template ID or name, and creates a VM instance from the given template. You can create more than one instance simultaneously with the `--multiple num_of_instances` option.

```
$ onetemplate instantiate 6
VM ID: 0

$ onevm list
  ID  USER   GROUP   NAME    STAT  CPU  MEM  HOSTNAME  TIME
  0   oneuser1 users one-0   pend  0  OK          00 00:00:16
```

**Merge Use Case**

The template merge functionality, combined with the restricted attributes, can be used to allow users some degree of customization for predefined templates.

Let's say the administrator wants to provide base templates that the users can customize, but with some restrictions.
Having the following restricted attributes in oned.conf:

```
VM_RESTRICTED_ATTR = "CPU"
VM_RESTRICTED_ATTR = "VPU"
VM_RESTRICTED_ATTR = "NIC"
```

And the following template:

```
CPU = "1"
VCPU = "1"
MEMORY = "512"
DISK=[
  IMAGE_ID = "0"
]
NIC=[
  NETWORK_ID = "0"
]
```

Users can instantiate it customizing anything except the CPU, VCPU and NIC. To create a VM with different memory and disks:

```
$ onetemplate instantiate 0 --memory 1G --disk "Ubuntu 16.04"
```

**Warning:** The merged attributes replace the existing ones. To add a new disk, the current one needs to be added also.

```
$ onetemplate instantiate 0 --disk 0,"Ubuntu 16.04"
```

```
$ cat /tmp/file
MEMORY = 512
COMMENT = "This is a bigger instance"
$ onetemplate instantiate 6 /tmp/file
VM ID: 1
```

**Deployment**

The OpenNebula Scheduler will deploy automatically the VMs in one of the available Hosts, if they meet the requirements. The deployment can be forced by an administrator using the `onevm deploy` command.

Use `onevm terminate` to shutdown and delete a running VM.

Continue to the *Managing Virtual Machine Instances Guide* to learn more about the VM Life Cycle, and the available operations that can be performed.

**Instantiating as a user and/or group**

From Sunstone:
From the CLI: the `onetemplate instantiate` command accepts option `--as_uid` and `--as_gid` with the User ID or Group ID to define which will be the owner or group for the VM.
4.3.4 Managing Templates

Users can manage the VM Templates using the command `onetemplate`, or the graphical interface Sunstone. For each user, the actual list of templates available are determined by the ownership and permissions of the templates.

Adding and Deleting Templates

Using `onetemplate create`, users can create new Templates for private or shared use. The `onetemplate delete` command allows the Template owner -or the OpenNebula administrator- to delete it from the repository.

For instance, if the previous example template is written in the `vm-example.txt` file:

```
$ onetemplate create vm-example.txt
ID: 6
```

Via Sunstone, you can easily add templates using the provided wizards (or copy/pasting a template file) and delete them clicking on the delete button:
Cloning Templates

You can also clone an existing Template with the `onetemplate clone` command:

```
$ onetemplate clone 6 new_template
ID: 7
```

If you use the `onetemplate clone --recursive` option, OpenNebula will clone each one of the Images used in the Template Disks. These Images are made persistent, and the cloned template DISK/IMAGE_ID attributes are replaced to point to them.
Updating a Template

It is possible to update a template by using the `onetemplate update`. This will launch the editor defined in the variable `EDITOR` and let you edit the template.

```
$ onetemplate update 3
```

Sharing Templates

The users can share their Templates with other users in their group, or with all the users in OpenNebula. See the Managing Permissions documentation for more information.

Let’s see a quick example. To share the Template 0 with users in the group, the `USE` right bit for `GROUP` must be set with the `chmod` command:

```
$ onetemplate show 0
...
PERMISSIONS
OWNER : um-
GROUP  : ---
OTHER  : ---

$ onetemplate chmod 0 640
$ onetemplate show 0
...
```
The following command allows users in the same group USE and MANAGE the Template, and the rest of the users USE it:

```bash
$ onetemplate chmod 0 664
$ onetemplate show 0
...
PERMISSIONS
OWNER : um-
GROUP : u--
OTHER : ---
```

The `onetemplate chmod --recursive` option will perform the chmod action also on each one of the Images used in the Template disks.

Sunstone offers an “alias” for `onetemplate chmod --recursive 640`, the share action:

### 4.4 Managing Virtual Machines Instances

This guide follows the *Creating Virtual Machines guide*. Once a Template is instantiated to a Virtual Machine, there are a number of operations that can be performed using the `onevm` command.
## 4.4.1 Virtual Machine Life-cycle

The life-cycle of a Virtual Machine within OpenNebula includes the following stages:

**Note:** Note that this is a simplified version. If you are a developer you may want to take a look at the complete diagram referenced in the [Virtual Machines States Reference guide](#).

<table>
<thead>
<tr>
<th>Short state</th>
<th>State</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>pend</td>
<td>Pending</td>
<td>By default a VM starts in the pending state, waiting for a resource to run on. It will stay in this state until the scheduler decides to deploy it, or the user deploys it using the <code>onevm deploy</code> command.</td>
</tr>
<tr>
<td>hold</td>
<td>Hold</td>
<td>The owner has held the VM and it will not be scheduled until it is released. It can be, however, deployed manually.</td>
</tr>
<tr>
<td>clon</td>
<td>Cloning</td>
<td>The VM is waiting for one or more disk images to finish the initial copy to the repository (image state still in lock)</td>
</tr>
<tr>
<td>prof</td>
<td>Prolog</td>
<td>The system is transferring the VM files (disk images and the recovery file) to the host in which the virtual machine will be running.</td>
</tr>
<tr>
<td>boot</td>
<td>Boot</td>
<td>OpenNebula is waiting for the hypervisor to create the VM.</td>
</tr>
<tr>
<td>runn</td>
<td>Running</td>
<td>The VM is running (note that this stage includes the internal virtualized machine booting and shutting down phases). In this state, the virtualization driver will periodically monitor it.</td>
</tr>
<tr>
<td>migr</td>
<td>Migrate</td>
<td>The VM is migrating from one resource to another. This can be a life migration or cold migration (the VM is saved, powered-off or powered-off hard and VM files are transferred to the new resource).</td>
</tr>
<tr>
<td>hotp</td>
<td>Hotplug</td>
<td>A disk attach/detach, nic attach/detach operation is in process.</td>
</tr>
<tr>
<td>snap</td>
<td>Save</td>
<td>A system snapshot is being taken.</td>
</tr>
<tr>
<td>save</td>
<td>Save</td>
<td>The system is saving the VM files after a migration, stop or suspend operation.</td>
</tr>
<tr>
<td>epil</td>
<td>Epilog</td>
<td>In this phase the system cleans up the Host used to virtualize the VM, and additionally disk images to be saved are copied back to the system datastore.</td>
</tr>
<tr>
<td>shut</td>
<td>Shutdown</td>
<td>OpenNebula has sent the VM the shutdown ACPI signal, and is waiting for it to complete the shutdown process. If after a timeout period the VM does not disappear, OpenNebula will assume that the guest OS ignored the ACPI signal and the VM state will be changed to running, instead of done.</td>
</tr>
<tr>
<td>stop</td>
<td>Stopped</td>
<td>The VM is stopped. VM state has been saved and it has been transferred back along with the disk images to the system datastore.</td>
</tr>
<tr>
<td>susp</td>
<td>Suspended</td>
<td>Same as stopped, but the files are left in the host to later resume the VM there (i.e. there is no need to re-schedule the VM).</td>
</tr>
<tr>
<td>poff</td>
<td>PowerOff</td>
<td>Same as suspended, but no checkpoint file is generated. Note that the files are left in the host to later boot the VM there. When the VM guest is shutdown, OpenNebula will put the VM in this state.</td>
</tr>
<tr>
<td>unde</td>
<td>Undeployed</td>
<td>The VM is shut down. The VM disks are transferred to the system datastore. The VM can be resumed later.</td>
</tr>
<tr>
<td>fail</td>
<td>Failed</td>
<td>The VM failed.</td>
</tr>
<tr>
<td>unkn</td>
<td>Unknown</td>
<td>The VM couldn’t be reached, it is in an unknown state.</td>
</tr>
<tr>
<td>clea</td>
<td>Cleanup</td>
<td>The VM is waiting for the drivers to clean the host after a <code>onevm recover --recreate</code> action</td>
</tr>
<tr>
<td>done</td>
<td>Done</td>
<td>The VM is done. VMs in this state won’t be shown with <code>onevm list</code> but are kept in the database for accounting purposes. You can still get their information with the <code>onevm show</code> command.</td>
</tr>
</tbody>
</table>
4.4.2 Managing Virtual Machines

The following sections show the basics of the `onevm` command with simple usage examples. A complete reference for these commands can be found here.

Create and List Existing VMs

**Note:** Read the *Creating Virtual Machines guide* for more information on how to manage and instantiate VM Templates.

**Note:** Read the complete reference for *Virtual Machine templates.*
Assuming we have a VM Template registered called `vm-example` with ID 6, then we can instantiate the VM issuing:

```
$ onetemplate list
```

```
ID USER GROUP NAME REGTIME
6 oneadmin oneadmin vm_example 09/28 06:44:07
```

```
$ onetemplate instantiate vm-example --name my_vm
VM ID: 0
```

If the template has `USER INPUTS` defined the CLI will prompt the user for these values:

```
$ onetemplate instantiate vm-example --name my_vm
There are some parameters that require user input.
* (BLOG_TITLE) Blog Title: <my_title>
* (DB_PASSWORD) Database Password:
VM ID: 0
```
Afterwards, the VM can be listed with the `onevm list` command. You can also use the `onevm top` command to list VMs continuously.

```
$ onevm list
  ID  USER    GROUP   NAME      STAT CPU MEM    HOSTNAME    TIME
  0   oneadmin oneadmin my_vm  pend  0  0K     00 00:00:03
```

After a Scheduling cycle, the VM will be automatically deployed. But the deployment can also be forced by oneadmin using `onevm deploy`:

```
$ onehost list
  ID  NAME  RVM  TCPU  FCPU  ACPU  TMEM  FMEM  AMEM  STAT
  2   testbed 0  800  800  800   16G  16G  16G   on

$ onevm deploy 0 2

$ onevm list
  ID  USER    GROUP   NAME      STAT CPU MEM    HOSTNAME    TIME
  0   oneadmin oneadmin my_vm  runn  0  0K     testbed 00 00:02:40
```

and details about it can be obtained with `show`:

```
$ onevm show 0
VIRTUAL MACHINE 0 INFORMATION
ID : 0
NAME : my_vm
USER : oneadmin
GROUP : oneadmin
STATE : ACTIVE
LCM_STATE : RUNNING
START TIME : 04/14 09:00:24
END TIME : -
DEPLOY ID: : one-0

PERMISSIONS
OWNER : um-
GROUP : ---
OTHER : ---

VIRTUAL MACHINE MONITORING
NET_TX : 13.05
NET_RX : 0
USED MEMORY : 512
USED CPU : 0

VIRTUAL MACHINE TEMPLATE
...

VIRTUAL MACHINE HISTORY
SEQ  HOSTNAME REASON   START   TIME   PTIME
0    testbed none 09/28 06:48:18 00 00:07:23 00 00:00:00
```

Searching VM Instances...

You can search for VM instances by using the `--search` option of the `onevm list` command. This is specially useful on large environments with many VMs. The filter must be in a KEY=VALUE format and will return all the VMs which fit the filter.
The KEY must be in the VM template section or be one of the following:

- UNAME
- GNAME
- NAME
- LAST_POLL
- PREV_STATE
- PREV_LCM_STATE
- RESCHED
- STIME
- ETIME
- DEPLOY_ID

For example, for searching a VM with a specific MAC address:

```bash
$ onevm list --search MAC=02:00:0c:00:4c:dd
```

```
ID USER GROUP NAME STAT UCPU UMEM HOST TIME
21005 oneadmin oneadmin test-vm pend 0 0K 1d 23h11
```

Equivalently if there are more than one VM instance that matches the result they will be shown. For example, VMs with a given NAME:

```bash
$ onevm list --search NAME=test-vm
```

```
ID USER GROUP NAME STAT UCPU UMEM HOST TIME
21005 oneadmin oneadmin test-vm pend 0 0K 1d 23h13
2100 oneadmin oneadmin test-vm pend 0 0K 12d 17h59
```

**Warning:** This feature is only available for MySQL backend with a version higher or equal than 5.6.

### Terminating VM Instances...

You can terminate an instance with the `onevm terminate` command, from any state. It will shutdown (if needed) and delete the VM. This operation will free the resources (images, networks, etc) used by the VM.

If the instance is running, there is a `--hard` option that has the following meaning:

- **terminate**: Gracefully shuts down and deletes a running VM, sending the ACPI signal. Once the VM is shutdown the host is cleaned, and persistent and deferred-snapshot disk will be moved to the associated datastore. If after a given time the VM is still running (e.g. guest ignoring ACPI signals), OpenNebula will returned the VM to the `RUNNING` state.

- **terminate --hard**: Same as above but the VM is immediately destroyed. Use this action instead of `terminate` when the VM doesn’t have ACPI support.

### Pausing VM Instances...

There are two different ways to temporarily stop the execution of a VM: short and long term pauses. A **short term** pause keeps all the VM resources allocated to the hosts so its resume its operation in the same hosts quickly. Use the following `onevm` commands or Sunstone actions:

---

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• **suspend**: the VM state is saved in the running Host. When a suspended VM is resumed, it is immediately deployed in the same Host by restoring its saved state.

• **poweroff**: Gracefully powers off a running VM by sending the ACPI signal. It is similar to suspend but without saving the VM state. When the VM is resumed it will boot immediately in the same Host.

• **poweroff --hard**: Same as above but the VM is immediately powered off. Use this action when the VM doesn’t have ACPI support.

**Note:** When the guest is shutdown from within the VM, OpenNebula will put the VM in the **poweroff** state.

You can also plan a **long term pause**. The Host resources used by the VM are freed and the Host is cleaned. Any needed disk is saved in the system datastore. The following actions are useful if you want to preserve network and storage allocations (e.g. IPs, persistent disk images):

• **undeploy**: Gracefully shuts down a running VM, sending the ACPI signal. The Virtual Machine disks are transferred back to the system datastore. When an undeployed VM is resumed, it is be moved to the pending state, and the scheduler will choose where to re-deploy it.

• **undeploy --hard**: Same as above but the running VM is immediately destroyed.

• **stop**: Same as undeploy but also the VM state is saved to later resume it.

When the VM is successfully paused you can resume its execution with:

• **resume**: Resumes the execution of VMs in the stopped, suspended, undeployed and poweroff states.

**Rebooting VM Instances...**

Use the following commands to reboot a VM:

• **reboot**: Gracefully reboots a running VM, sending the ACPI signal.

• **reboot --hard**: Performs a ‘hard’ reboot.

**Delaying VM Instances...**

The deployment of a PENDING VM (e.g. after creating or resuming it) can be delayed with:

• **hold**: Sets the VM to hold state. The scheduler will not deploy VMs in the hold state. Please note that VMs can be created directly on hold, using `onetemplate instantiate –hold` or `onevm create –hold`.

Then you can resume it with:

• **release**: Releases a VM from hold state, setting it to pending. Note that you can automatically release a VM by scheduling the operation as explained below

**Disk Snapshots**

There are two kinds of operations related to disk snapshots:

• **disk-snapshot-create**, **disk-snapshot-revert**, **disk-snapshot-delete**, **disk-snapshot-rename**: Allows the user to take snapshots of the disk states and return to them during the VM life-cycle. It is also possible to rename or delete snapshots.

• **disk-saveas**: Exports VM disk (or a previously created snapshot) to an image. This is a live action.
Warning: Disk Snapshots are not supported in vCenter

Managing Disk Snapshots

A user can take snapshots of the disk states at any moment in time (if the VM is in RUNNING, POWEROFF or SUSPENDED states). These snapshots are organized in a tree-like structure, meaning that every snapshot has a parent, except for the first snapshot whose parent is -1. At any given time a user can revert the disk state to a previously taken snapshot. The active snapshot, the one the user has last reverted to, or taken, will act as the parent of the next snapshot. In addition, it’s possible to delete snapshots that are not active and that have no children.

Warning: The default behavior described previously can be overridden by the storage driver; and it may allow a flat snapshot structure without parent/child relationship. In that case, snapshots can be freely removed.

- `disk-snapshot-create <vmid> <diskid> <name>`: Creates a new snapshot of the specified disk.
- `disk-snapshot-revert <vmid> <diskid> <snapshot_id>`: Reverts to the specified snapshot. The snapshots are immutable, therefore the user can revert to the same snapshot as many times as he wants, the disk will return always to the state of the snapshot at the time it was taken.
- `disk-snapshot-delete <vmid> <diskid> <snapshot_id>`: Deletes a snapshot if it has no children and is not active.

disk-snapshot-create can take place when the VM is in RUNNING state, provided that the drivers support it, while disk-snapshot-revert requires the VM to be POWEROFF or SUSPENDED. Live snapshots are only supported for some drivers:

- Hypervisor VM_MAD=kvm combined with TM_MAD=qcow2 datastores. In this case OpenNebula will request that the hypervisor executes `virsh snapshot-create`.
- Hypervisor VM_MAD=kvm with Ceph datastores (TM_MAD=ceph). In this case OpenNebula will initially create the snapshots as Ceph snapshots in the current volume.
With CEPH and qcow2 datastores and KVM hypervisor you can enable QEMU Guest Agent. With this agent enabled the filesystem will be frozen while the snapshot is being done.

OpenNebula will not automatically handle non-live disk-snapshot-create and disk-snapshot-revert operations for VMs in RUNNING if the drivers do not support it. In this case the user needs to suspend or poweroff the VM before creating the snapshot.

See the Storage Driver guide for a reference on the driver actions invoked to perform live and non-live snapshot.

**Persistent Image Snapshots**

These actions are available for both persistent and non-persistent images. In the case of persistent images the snapshots will be preserved upon VM termination and will be able to be used by other VMs using that image. See the *snapshots* section in the Images guide for more information.

**Back-end Implementations**

The snapshot operations are implemented differently depending on the storage back-end:

<table>
<thead>
<tr>
<th>Operation/TM_MAD</th>
<th>Ceph MAD</th>
<th>Shared and SSH</th>
<th>Qcow2</th>
<th>Dev, FS_LVM, LVM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snap Create</td>
<td>Creates a protected snapshot</td>
<td>Copies the file.</td>
<td>Creates a new qcow2 image with the previous disk as the backing file.</td>
<td>Not Supported</td>
</tr>
<tr>
<td>Snap Create (live)</td>
<td>Creates a protected snapshot and quiesces the guest fs.</td>
<td>Not Supported</td>
<td>(For KVM only) Launches virsh snapshot-create.</td>
<td>Not Supported</td>
</tr>
<tr>
<td>Snap Revert</td>
<td>Overwrites the active disk by creating a new snapshot of an existing protected snapshot</td>
<td>Overwrites the file with a previously copied one.</td>
<td>Creates a new qcow2 image with the selected snapshot as the backing file.</td>
<td>Not Supported</td>
</tr>
<tr>
<td>Snap Delete</td>
<td>Deletes a protected snapshot</td>
<td>Deletes the file.</td>
<td>Deletes the selected qcow2 snapshot.</td>
<td>Not Supported</td>
</tr>
</tbody>
</table>

**Warning:** Depending on the DISK/CACHE attribute the live snapshot may or may not work correctly. To be sure, you can use CACHE=writethrough, although this delivers the slowest performance.

**Exporting Disk Images with disk-saveas**

Any VM disk can be exported to a new image (if the VM is in RUNNING, POWEROFF or SUSPENDED states). This is a live operation that happens immediately. This operation accepts --snapshot <snapshot_id> as an optional argument, which specifies a disk snapshot to use as the source of the clone, instead of the current disk state (value by default).

**Warning:** This action is not in sync with the hypervisor. If the VM is in RUNNING state make sure the disk is unmounted (preferred), synced or quiesced in some way or another before taking the snapshot.
**Note:** In vCenter, the save as operation can only be performed when the VM is in POWEROFF state. Performing this action in a different state won’t work as vCenter cannot unlock the VMDK file.

**Disk Hot-plugging**

New disks can be hot-plugged to running VMs with the `onevm disk-attach` and `disk-detach` commands. For example, to attach to a running VM the Image named `storage`:

```bash
$ onevm disk-attach one-5 --image storage
```

To detach a disk from a running VM, find the disk ID of the Image you want to detach using the `onevm show` command, and then simply execute `onevm detach vm_id disk_id`:

```bash
$ onevm show one-5
...
DISK=[
  DISK_ID="1",
  ...
]
...
$ onevm disk-detach one-5 1
```

**Attach new disk**

![Virtual Machine ID:](image)

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Datastore</th>
<th>Type</th>
<th>Status</th>
<th>#VMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>My Saved Template</td>
<td>default</td>
<td>OS</td>
<td>READY</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Dev Environment</td>
<td>default</td>
<td>OS</td>
<td>READY</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>CentOS with Apache</td>
<td>default</td>
<td>OS</td>
<td>READY</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>My saved template</td>
<td>default</td>
<td>OS</td>
<td>READY</td>
<td>0</td>
</tr>
</tbody>
</table>

You selected the following image: [Dev Environment]

Advanced options

**4.4. Managing Virtual Machines Instances** 143
NIC Hot-plugging

You can hot-plug network interfaces to VMs in the RUNNING, POWEROFF or SUSPENDED states. Simply specify the network where the new interface should be attached to, for example:

```
$ onevm show 2

VIRTUAL MACHINE 2 INFORMATION
ID               : 2
NAME             : centos-server
STATE            : ACTIVE
LCM_STATE        : RUNNING

VM NICS
ID NETWORK      VLAN BRIDGE IP               MAC
0 net_172       no vbr0          172.16.0.201 02:00:ac:10:00:ca

$ onevm nic-attach 2 --network net_172

After the operation you should see two NICs, 0 and 1:

```
$ onevm show 2

VIRTUAL MACHINE 2 INFORMATION
ID               : 2
NAME             : centos-server
STATE            : ACTIVE
LCM_STATE        : RUNNING

VM NICS
ID NETWORK      VLAN BRIDGE IP               MAC
0 net_172       no vbr0          172.16.0.201 02:00:ac:10:00:ca
0 fe80::400:acff:fe10:00:ca
1 net_172       no vbr0          172.16.0.202 02:00:ac:10:00:ca
1 fe80::400:acff:fe10:ca

You can also detach a NIC by its ID. If you want to detach interface 1 (MAC 02:00:ac:10:00:ca), execute:

```
$ onevm nic-detach 2 1
```
Snapshotting

You can create, delete and restore snapshots for running VMs. A snapshot will contain the current disks and memory state.

```
$ onevm snapshot-create 4 "just in case"

$ onevm show 4
...
SNAPSHOTS
ID  TIME   NAME                HYPERVERSOR_ID
 0  02/21 16:05 just in case  onesnap-0

$ onevm snapshot-revert 4 0 --verbose
VM 4: snapshot reverted
```

**Warning:** **For KVM only.** Please take into consideration the following limitations:

- The snapshots are lost if any life-cycle operation is performed, e.g. a suspend, migrate, delete request.
- Snapshots are only available if all the VM disks use the *qcow2* driver.
Resizing VM Capacity

You may resize the capacity assigned to a Virtual Machine in terms of the virtual CPUs, memory and CPU allocated. VM resizing can be done in any of the following states: POWEROFF, UNDEPLOYED.

If you have created a Virtual Machine and you need more resources, the following procedure is recommended:

- Perform any operation needed to prepare your Virtual Machine for shutting down, e.g. you may want to manually stop some services
- Poweroff the Virtual Machine
- Resize the VM
- Resume the Virtual Machine using the new capacity

Note that using this procedure the VM will preserve any resource assigned by OpenNebula, such as IP leases.

The following is an example of the previous procedure from the command line:

```bash
$ onevm poweroff web_vm
$ onevm resize web_vm --memory 2G --vcpu 2
$ onevm resume web_vm
```

From Sunstone:

4.4. Managing Virtual Machines Instances
Resizing VM Disks

If the disks assigned to a Virtual Machine need more size, this can achieved at instantiation time of the VM. The SIZE parameter of the disk can be adjusted and, if it is bigger than the original size of the image, OpenNebula will:

- Increase the size of the disk container prior to launching the VM
- Using the contextualization packages, at boot time the VM will grow the filesystem to adjust to the new size.

This is only available for Linux guests in KVM and vCenter.

This can be done with an extra file given to the instantiate command:

```
$ cat /tmp/disk.txt
DISK = [ IMAGE_ID = 4,
        SIZE = 2000]  # If Image 4 is 1 GB, OpenNebula will resize it to 2 GB
```

```
$ onetemplate instantiate 7 /tmp/disk.txt
```

Or with CLI options:

```
$ onetemplate instantiate <template> --disk image0:size=20000
```

This can also be achieved from Sunstone, both in Cloud and Admin View, at the time of instantiating a VM Template:
**Important:** In vCenter a disk can be resized only if the VM is in poweroff state and the VM has no snapshots or the template, which the VM is based on, doesn’t use linked clones.

**Updating VM Configuration**

Some of the VM configuration attributes defined in the VM Template can be updated after the VM is created. The `onevm updateconf` command will allow you to change the following attributes:
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Sub-attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS</td>
<td>ARCH, MACHINE, KERNEL, INITRD, BOOTLOADER, BOOT, SD_DISK_BUS</td>
</tr>
<tr>
<td>FEATURES</td>
<td>ACPI, PAE, APIC, LOCALTIME, HYPERV, GUEST_AGENT</td>
</tr>
<tr>
<td>INPUT</td>
<td>TYPE, BUS</td>
</tr>
<tr>
<td>GRAPHICS</td>
<td>TYPE, LISTEN, PASSWD, KEYMAP</td>
</tr>
<tr>
<td>RAW</td>
<td>DATA, DATA_VMX, TYPE</td>
</tr>
<tr>
<td>CONTEXT</td>
<td>Any value. Variable substitution will be made</td>
</tr>
</tbody>
</table>

**Note:** Visit the *Virtual Machine Template reference* for a complete description of each attribute.

**Warning:** If the VM is running, the action may fail and the context will not be changed. You can try to manually trigger the action again.

**Note:** Changes on GRAPHIC will still require the VM to be restarted despite being updatable.

In Sunstone this action is inside the ‘Conf’ VM panel:
Cloning a VM

A VM Template or VM instance can be copied to a new VM Template. This copy will preserve the changes made to the VM disks after the instance is terminated. The template is private, and will only be listed to the owner user.

There are two ways to create a persistent private copy of a VM:

- Instantiate a template ‘to persistent’
- Save a existing VM instance with `onevm save`

**Instantiate to persistent**

When **instantiating to persistent** the Template is cloned recursively (a private persistent clone of each disk Image is created), and that new Template is instantiated.

To “instantiate to persistent” use the **--persistent** option:

```bash
$ onetemplate instantiate web_vm --persistent --name my_vm
VM ID: 31

$ onetemplate list
<table>
<thead>
<tr>
<th>ID</th>
<th>USER</th>
<th>GROUP</th>
<th>NAME</th>
<th>REGTIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>oneadmin</td>
<td>oneadmin</td>
<td>web_vm</td>
<td>05/12 14:53:11</td>
</tr>
<tr>
<td>8</td>
<td>oneadmin</td>
<td>oneadmin</td>
<td>my_vm</td>
<td>05/12 14:53:38</td>
</tr>
</tbody>
</table>

$ oneimage list
<table>
<thead>
<tr>
<th>ID</th>
<th>USER</th>
<th>GROUP</th>
<th>NAME</th>
<th>DATASTORE</th>
<th>SIZE</th>
<th>TYPE</th>
<th>PER</th>
<th>STAT</th>
<th>RVMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>oneadmin</td>
<td>oneadmin</td>
<td>web-img</td>
<td>default</td>
<td>200M</td>
<td>OS</td>
<td>Yes</td>
<td>used</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>oneadmin</td>
<td>oneadmin</td>
<td>my_vm-disk-0</td>
<td>default</td>
<td>200M</td>
<td>OS</td>
<td>Yes</td>
<td>used</td>
<td>1</td>
</tr>
</tbody>
</table>
In Sunstone, activate the “Persistent” switch next to the create button:

![Create Virtual Machine](image)

Please bear in mind the following `ontemplate instantiate --persistent` limitation:

- Volatile disks cannot be persistent, and the contents will be lost when the VM is terminated. The cloned VM Template will contain the definition for an empty volatile disk.

## Save a VM Instance

Alternatively, a VM that was not created as persistent can be `saved` before it is destroyed. To do so, the user has to `poweroff` the VM first and then use the `save` operation.

This action clones the VM source Template, replacing the disks with snapshots of the current disks (see the disk-snapshot action). If the VM instance was resized, the current capacity is also used. The new cloned Images can be made persistent with the `--persistent` option. NIC interfaces are also overwritten with the ones from the VM instance, to preserve any attach/detach action.

```
$ onevm save web_vm copy_of_web_vm --persistent
Template ID: 26
```

In the *Cloud View*:
This Virtual Machine will be saved in a new Template. You can then create a new Virtual Machine using this Template.

Template Name

The new Virtual Machine’s disks can be made persistent. In a persistent Virtual Machine the changes made survive after it is destroyed. On the other hand, you cannot create more than one simultaneous Virtual Machine from a Template with persistent disks.

☐ Persistent  ☐ Non-persistent

Save Virtual Machine to Template

From the Admin View:

```
<table>
<thead>
<tr>
<th>VM</th>
<th>tty-4</th>
<th>POWEROFF</th>
</tr>
</thead>
</table>
```

No actions to show
Please bear in mind the following `onevm save` limitations:

- The VM’s source Template will be used. If this Template was updated since the VM was instantiated, the new contents will be used.
- Volatile disks cannot be saved, and the current contents will be lost. The cloned VM Template will contain the definition for an empty volatile disk.
- Disks and NICs will only contain the target Image/Network ID. If your Template requires extra configuration (such as DISK/DEV_PREFIX), you will need to update the new Template.

### Scheduled Actions

We have two types of schedule actions, punctual and relative actions. Punctual actions can also be periodic.

#### One-Time Punctual Actions

Most of the `onevm` commands accept the `--schedule` option, allowing users to delay the actions until the given date and time.

Here is an usage example:

```bash
$ onevm suspend 0 --schedule "09/20"
VM 0: suspend scheduled at 2016-09-20 00:00:00 +0200

$ onevm resume 0 --schedule "09/23 14:15"
VM 0: resume scheduled at 2016-09-23 14:15:00 +0200

$ onevm show 0
VIRTUAL MACHINE 0 INFORMATION
ID : 0
NAME : one-0

[...]

SCHEDULED ACTIONS
ID ACTION SCHEDULED REP END
0 suspend 09/20 00:00

These actions can be deleted or edited using the `onevm update` command. The time attributes use Unix time internally.

```bash
$ onevm update 0
SCHED_ACTION=[
    ACTION="suspend",
    ID="0",
    TIME="1379628000"
]
SCHED_ACTION=[
    ACTION="resume",
]
Periodic Punctual Actions

To schedule periodic actions also use the option --schedule. However this command also needs more options to define the periodicity of the action.

- **--weekly**: defines a weekly periodicity, so, the action will be execute all weeks, the days that the user defines.
- **--monthly**: defines a monthly periodicity, so, the action will be execute all months, the days that the user defines.
- **--yearly**: defines a yearly periodicity, so, the action will be execute all year, the days that the user defines.
- **--hourly**: defines a hourly periodicity, so, the action will be execute each ‘x’ hours.
- **--end**: defines when you want that the relative action finishes.

The option --weekly, --monthly and --yearly need the number of the days that the users wants execute the action.

- **--weekly**: days separate with commas between 0 and 6. [0,6]
- **--monthly**: days separate with commas between 1 and 31. [0,31]
- **--weekly**: days separate with commas between 0 and 365. [0,365]

The option --hourly needs a number with the number of hours. [0,168] (1 week)

The option --end can be a number or a date:

- **Number**: defines the number of repetitions.
- **Date**: defines the date that the user wants to finished the action.

Here is an usage example:

```bash
$ onevm suspend 0 --schedule "09/20" --weekly "1,5" --end 5
VM 0: suspend scheduled at 2018-09-20 00:00:00 +0200

$ onevm resume 0 --schedule "09/23 14:15" --weekly "2,6" --end 5
VM 0: resume scheduled at 2018-09-23 14:15:00 +0200

$ onevm snapshot-create 0 --schedule "09/23" --hourly 10 --end "12/25"
VM 0: snapshot created at 2018-09-23 14:15:00 +0200

$ onevm show 0
VIRTUAL MACHINE 0 INFORMATION
  ID : 0
  NAME : one-0

[...]

SCHEDULED ACTIONS
  ID ACTION      SCHEDULED   REP          END     
  DONE MESSAGE  0 suspend  09/23 00:00  Weekly 1,5  After 5 times
```
These actions can be deleted or edited using the `onevm update` command. The time attributes use Unix time internally.

```
$ onevm update 0

SCHED_ACTION=[
    ACTION="suspend",
    DAYS="1,5",
    END_TYPE="1",
    END_VALUE="5",
    ID="0",
    REPEAT="0",
    TIME="1537653600" ]
SCHED_ACTION=[
    ACTION="resume",
    DAYS="2,6",
    END_TYPE="1",
    END_VALUE="5",
    ID="1",
    REPEAT="0",
    TIME="1537653600" ]
SCHED_ACTION=[
    ACTION="snapshot-create",
    DAYS="5",
    END_TYPE="2",
    END_VALUE="1545692400",
    ID="2",
    REPEAT="3",
    TIME="1537653600" ]
```

### Relative Actions

Scheduled actions can be also relative to the Start Time of the VM. That is, it can be set on a VM Template, and apply to the number of seconds after the VM is instantiated.

For instance, a VM Template with the following SCHED_ACTION will spawn VMs that will automatically shutdown after 1 hour of being instantiated.

```
$ onetemplate update 0

SCHED_ACTION=[
    ACTION="terminate",
    ID="0",
    TIME="+3600" ]
```

This functionality is present graphically in Sunstone in the VM Template creation and update dialog, and in the VM Actions tab:
These are the commands that can be scheduled:

- `terminate [--hard]`
- `undeploy [--hard]`
- `hold`
- `release`
- `stop`
- `suspend`
- `resume`
- `delete`
- `delete-recreate`
- `reboot [--hard]`
- `poweroff [--hard]`
- `snapshot-create`

**User Defined Data**

Custom attributes can be added to a VM to store metadata related to this specific VM instance. To add custom attributes simply use the `onevm update` command.
Manage VM Permissions

OpenNebula comes with an advanced ACL rules permission mechanism intended for administrators, but each VM object has also implicit permissions that can be managed by the VM owner. To share a VM instance with other users, to allow them to list and show its information, use the `onevm chmod` command:

```
$ onevm show 0
...
PERMISSIONS
OWNER : um-
GROUP : ---
OTHER : ---
$ onevm chmod 0 640

$ onevm show 0
...
PERMISSIONS
OWNER : um-
GROUP : u--
OTHER : ---
```

Administrators can also change the VM’s group and owner with the `chgrp` and `chown` commands.

Life-Cycle Operations for Administrators

There are some `onevm` commands operations meant for the cloud administrators:

Scheduling:

- `resched`: Sets the reschedule flag for the VM. The Scheduler will migrate (or migrate –live, depending on the Scheduler configuration) the VM in the next monitorization cycle to a Host that better matches the requirements and rank restrictions. Read more in the Scheduler documentation.
• **unresched**: Clears the reschedule flag for the VM, canceling the rescheduling operation.

**Deployment:**

• **deploy**: Starts an existing VM in a specific Host.

• **migrate --live**: The Virtual Machine is transferred between Hosts with no noticeable downtime. This action requires a shared file system storage.

• **migrate**: The VM gets stopped and resumed in the target host. In an infrastructure with *multiple system datastores*, the VM storage can be also migrated (the datastore id can be specified).

**Note**: By default, the above operations do not check the target host capacity. You can use the **--enforce** option to be sure that the host capacity is not overcommitted.

**Troubleshooting:**

• **recover**: If the VM is stuck in any other state (or the boot operation does not work), you can recover the VM with the following options. Read the Virtual Machine Failures guide for more information.
  
  – **--success**: simulates the success of the missing driver action
  
  – **--failure**: simulates the failure of the missing driver action
  
  – **--retry**: retries to perform the current driver action. Optionally the **--interactive** can be combined if it's a Transfer Manager problem.

  – **--delete**: Deletes the VM, moving it to the DONE state immediately

  – **--recreate**: Deletes the VM, and moves it to the PENDING state

• **migrate or resched**: A VM in the UNKNOWN state can be booted in a different host manually (**migrate**) or automatically by the scheduler (**resched**). This action must be performed only if the storage is shared, or manually transferred by the administrator. OpenNebula will not perform any action on the storage for this migration.

### 4.4.3 VNC/Spice Access through Sunstone

If the VM supports VNC or Spice and is running, then the VNC icon on the Virtual Machines view should be visible and clickable:

<table>
<thead>
<tr>
<th>ID</th>
<th>Owner</th>
<th>Group</th>
<th>Name</th>
<th>Status</th>
<th>Host</th>
<th>IPs</th>
<th>VNC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>onedir</td>
<td>oneadmin</td>
<td>ttylinux-0</td>
<td>RUNNING</td>
<td>localhost</td>
<td>192.168.122.2</td>
<td></td>
</tr>
</tbody>
</table>

Showing 1 to 1 of 1 entries
Note: In LXD instances, VNC access is provided through a command executed via `lxc exec <container> -- <command>`. By default this command is `/bin/login` and it can be updated by editing `/var/tmp/one/etc/vmm/lxd/lxdrc` in the LXD node.

The command can also be set for each container, by updating the `GRAPHICS` section in the VM template.
The Sunstone documentation contains a section on VNC troubleshooting.

### 4.4.4 Information for Developers and Integrators

- Although the default way to create a VM instance is to register a Template and then instantiate it, VMs can be created directly from a template file using the `onevm create` command.
- When a VM reaches the `done` state, it disappears from the `onevm list` output, but the VM is still in the database and can be retrieved with the `onevm show` command.
- OpenNebula comes with an accounting tool that reports resource usage data.
- The monitoring information, shown with nice graphs in Sunstone, can be retrieved using the XML-RPC methods `one.vm.monitoring` and `one.vmpool.monitoring`.

### 4.5 vCenter Specifics

#### 4.5.1 vCenter VM and VM Templates

To learn how to use VMs and VM Templates you can read the *Managing Virtual Machines Instances* and *Managing Virtual Machine Templates*, but first take into account the following considerations.

OpenNebula creates VM Templates using the import tools, but for your reference a VM Template definition in OpenNebula that represents a vCenter VM Template should contain the following attributes:
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Physical CPUs to be used by the VM. This does not have to relate to the CPUs used by the vCenter VM Template, OpenNebula will change the value accordingly</td>
</tr>
<tr>
<td>MEMORY</td>
<td>Physical Memory in MB to be used by the VM. This does not have to relate to the CPUs used by the vCenter VM Template, OpenNebula will change the value accordingly</td>
</tr>
<tr>
<td>HYPERVISOR</td>
<td>Should be set to vcenter</td>
</tr>
<tr>
<td>NIC</td>
<td>One or more NIC elements. Check VM template reference. Valid MODELS are: virtuale1000, virtuale1000e, virtualpcnet32, virtuallsriovethernetcard, virtualvmxnetm, virtualvmxnet2, virtualvmxnet3.</td>
</tr>
<tr>
<td>DISK</td>
<td>One or more DISK elements. Check VM template reference.</td>
</tr>
<tr>
<td>GRAPHICS</td>
<td>Multi-value - Only VNC supported, check the VM template reference.</td>
</tr>
<tr>
<td>CONTEXT</td>
<td>All sections will be honored except FILES. You can find more information about contextualization in the vcenter Contextualization section.</td>
</tr>
<tr>
<td>VCENTER_RESOURCE_POOL</td>
<td>(Optional) By default, the VM will be deployed to the default resource pool. If this attribute is set, its value will be used to confine this the VM in the referred resource pool. Check this section for more information.</td>
</tr>
<tr>
<td>VCENTER_VM_FOLDER</td>
<td>(Optional) If you use folders to group your objects like VMs and you want a VM to be placed in a specific folder, you can specify a Deployment Folder where the VM will be created. The Deployment Folder is a path which uses slashes to separate folders. More info in the VM cloning Section</td>
</tr>
<tr>
<td>VCENTER_TEMPREF</td>
<td>Managed Object Reference of the vCenter datastore. Please visit the Managed Object Reference section to know more about these references.</td>
</tr>
<tr>
<td>VCENTER_CCRREF</td>
<td>Managed Object Reference of the vCenter cluster related with the template. Please visit the Managed Object Reference section to know more about these references.</td>
</tr>
<tr>
<td>VCENTER_INSTID</td>
<td>The vCenter instance ID. Please visit the Managed Object Reference section to know more about these references.</td>
</tr>
</tbody>
</table>

After a VM Template is instantiated, the life-cycle of the resulting virtual machine (including creation of snapshots) can be controlled through OpenNebula. Also, all the operations available in the Admin view can be performed, including:

- network management operations like the ability to attach/detach network interfaces
- capacity (CPU and MEMORY) resizing
- VNC connectivity
- Attach/detach VMDK images as disks
- Resize VM disks (shrink not supported) before the VM is deployed or when the VM is in POWEROFF state.

The following operations are not available for vCenter VMs:

- migrate
- livemigrate

The monitoring attributes retrieved from a vCenter VM are:

- VCENTER_ESX_HOST: The ESX host where the VM is running
- VCENTER_GUEST_IP: IP address reported by VMWare Tools or Open VM Tools.
- VCENTER_GUEST_STATE: The state of the VM reported by VMWare Tools or Open VM Tools.
- VCENTER_RP_NAME: Resource Pool where the VM is running. Check this section for more information.
• VCENTER_VMWARETOOLS_RUNNING_STATUS: The status of VMWare Tools software or Open VM Tools software.
• VCENTER_VMWARETOOLS_VERSION: The version of the VMWare Tools or Open VM Tools.
• VCENTER_VMWARETOOLS_VERSION_STATUS: The status version of the VMWare Tools or Open VM Tools.
• VCENTER_DRS: The status of the vSphere DRS (Distributed Resource Scheduler).
• VCENTER_HA: The status of the vSphere HA (High Availability).
• NETTX: Bytes transmitted.
• NETRX: Bytes received.
• DISKRDBYTES: VM disks read bytes
• DISKRDIOPS: VM disks read IOPS
• DISKWRBYTES: VM disks write bytes
• DISKWRIOPS: VM disks write IOPS
• VCENTER_VM_NAME: VM name on vCenter

vCenter Template or Wild VM Importing Procedure

While a template or Wild VM is being imported, OpenNebula will inspect the virtual disks and virtual nics and it will create images and virtual networks referencing the disks and port-groups used by the VM. This process may take some time, please be patient.

You have more information about these procedures:
  • vCenter Template import
  • Wild VM import

VM Template Cloning Procedure

OpenNebula uses VMware cloning VM Template procedure to instantiate new Virtual Machines through vCenter. From the VMware documentation:

Deploying a virtual machine from a template creates a virtual machine that is a copy of the template. The new virtual machine has the virtual hardware, installed software, and other properties that are configured for the template.

The cloning procedure involves:
  • Choosing a datastore.
  • Specifying how the template disks are copied.
  • Selecting a Resource Pool where the VM will run if DRS is enabled in the vCenter cluster.
  • Deciding the folder where the VM will be placed inside the VM and Templates inventory view.
Choosing a datastore

By default, the VM will be deployed in the datastore that the OpenNebula’s scheduler chooses according to its policy. The policy is set in the /etc/one/sched.conf configuration file and by default OpenNebula will try to deploy the VMs trying to distribute them across the available datastores.

You can force that OpenNebula uses specific datastores overriding the scheduler’s policy with the SCHED_DS_REQUIREMENTS as explained here.

It’s compulsory that you import vCenter datastores before trying to deploy a VM and you must be sure that the datastores are shared by every ESX host in the cluster.

Specifying how the disks are copied

OpenNebula instructs vCenter to “move all disk backing an disallow sharing”. That means that vCenter will create a full clone of the disks inside the template, and that full clone flattens all disks from the parent-most to the child-most disk.

However if you import the template with Linked Clones support OpenNebula will “move only the child-most disk backing” which means that any parent disk backings should be left in their current locations and if the disks have delta disks on top of them, then linked clones of the template disks will be used.

You have more information about disk moving operations here and the use of Linked Clones here and here in OpenNebula docs.

Selecting a Resource Pool

OpenNebula uses the default cluster resource pool to place the VM instantiated from the VM template, unless VCENTER_RESOURCE_POOL variable is defined in the OpenNebula host template or VM template. You have more information about resource pools here in OpenNebula docs.

Deciding the VM folder in vSphere’s VM and Templates view

When the VM is cloned from the VM template, you can found that VM in vSphere’s Web Client is by default in the same location where the vCenter template is located. For instance, using the corelinux64 vcenter template I can find the OpenNebula’s VM with the one- prefix in the same folder where my template lives.

![Templates](image)

However you may place the VM in a different folder using the VCENTER_VM_FOLDER attribute as explained here in OpenNebula docs

Saving a VM Template: Instantiate to Persistent

At the time of deploying a VM Template, a flag can be used to create a new VM Template out of the VM.

```bash
$ onetemplate instantiate <tid> --persistent
```
You can also use this feature from Sunstone when you instantiate a template:

OpenNebula does the following when you use Instantiate to Persistent:

- A copy of every disk in the template is made and stored as OpenNebula images. Unmanaged disks which are disks that have OPENNEBULA_MANAGED attribute set to NO and that represents the disks that already exists in the vCenter template will be copied as non-persistent images. The rest of the disks will be represented as persistent images. Note that volatile disks won’t have an image associated.
- A new OpenNebula template will be created and the disks added in the previous step will be included in the template.
- Whenever the VM life-cycle ends (a VM terminate action), OpenNebula will instruct vCenter to create a new vCenter template out of the VM, with the settings of the VM.
- The OpenNebula VM template will point to the new vCenter template, so it can be instantiated through OpenNebula.

This functionality is very useful to create new VM Templates from a original VM Template, changing the VM configuration and/or installing new software, to create a complete VM Template catalog.

**Important:** Don’t detach disks from the VM or resize any disk of the VM once you’ve deployed it with Instantiate as Persistent, as when the VM is terminated the OpenNebula template that was created before the VM was deployed will differ from the template created in vCenter. Differences between the templates may affect operations on VMs based on unsynced templates.

**Saving a VM Template: Save As**

In the Sunstone’s cloud_vcenter view you can poweroff a VM an use the save icon to create a new OpenNebula template from this VM.

OpenNebula will offer to create a copy of the disks, select non-persistent images or persistent images.

a message will inform you that the new OpenNebula template has been created and the VM will show the state SAVING_IMAGE.
Refresh the VM state with the icon next to the VM’s name, you’ll see the VM in OFF state when your new OpenNebula template is ready to use in the templates tab.

Your new VM template will contain DISK elements that will point to the disk copies created and NIC elements that will point to the same OpenNebula virtual networks used by the VM this template is based on.

Note that the new OpenNebula template has a Managed Object Reference to the vCenter template used to create the original VM. This implies that when a VM is deployed from the new OpenNebula template, a VM will be cloned from the original vCenter template where the old disks will be detached and the disk copies that were created previously will be attached.

**VM Scheduling**

OpenNebula scheduler should only chose a particular OpenNebula host for a OpenNebula VM Template representing a vCenter VM Template, since it most likely only would be available in a particular vCenter cluster.

The scheduler will inspect the VM Template and it will choose to deploy the VM in an OpenNebula host which is member of an OpenNebula cluster that contains the datastores where the DISKs images are stored and that contains the virtual networks used by the NICs elements of the VM template. When a vCenter cluster is imported into OpenNebula an OpenNebula Host that represents that vCenter cluster is created and that OpenNebula Host is added to an OpenNebula Cluster that is created by default if no other OpenNebula cluster is selected. Note that if you import a vCenter template which has no disks or networks, OpenNebula Scheduler’s won’t be able to decide on which OpenNebula host (vCenter cluster) it can use to deploy the VM.

**Note:** If a VM is stuck in the PENDING state, that means that the scheduler hasn’t found a host and datastores that satisfies its requirement. In this case check that the images and networks defined in the VM template are located in an OpenNebula cluster other than the default cluster and check that the OpenNebula host is also assigned to the same OpenNebula cluster.

Since a vCenter cluster is an aggregation of ESX hosts, the ultimate placement of the VM on a particular ESX host would be managed by vCenter, in particular by the Distribute Resource Scheduler (DRS).

In Sunstone, a host abstracting a vCenter cluster will have an extra tab showing the ESX hosts that conform the cluster.
Attaching a CDROM to a Virtual Machine

You can attach a CDROM to a Virtual Machine creating first an OpenNebula image from an ISO file.

Then the CDROM can be attached to a Virtual Machine template or can be attached to deployed Virtual Machine, ONLY if the Virtual Machines is in the POWEROFF state. OpenNebula tries to connect the ISO file as an IDE CD-ROM drive which is not a hot-pluggable device that’s why the Virtual Machine must not be RUNNING (powered on).

4.5.2 Disks monitoring

OpenNebula gathers disks monitoring info for each VM providing metrics like the rate of reading/writing data to the VM’s virtual disks and the read/write IOPS. Real-time data is retrieved from vCenter thanks to the Performance Manager which collects data every 20 seconds and maintains it for one hour.

**Important:** OpenNebula requires that you set the right Statistics Level so disk metrics are generated and stored by vCenter. Increasing the statistics level implies that more space is needed to store metrics so check that you have enough storage before changing the level.

vCenter Statistics level for 5-minutes data must be set to 2.

The rate of reading/write is provided by vCenter as an average using KB/s unit. The graphs provided by Sunstone are different from those found in vCenter under the Monitor -> Performance Tab when selecting Realtime in the Time Range drop-down menu. The reason is that Sunstone uses polling time as time reference while vCenter uses sample time on their graphs, so an approximation to the real values aggregating vCenter’s samples between polls is needed. As a result, peaks may be different in value and different peaks between polls won’t be depicted. Sunstone’s graphs will provide a useful information about disks behaviour which can be examined on vCenter later with greater detail.
4.5.3 vCenter Images

You can follow the Managing Images Section to learn how to manage images, considering that VMDSK snapshots are not supported as well as the following considerations.

Existing disks in vCenter VM Templates or Wild VMs will be imported in OpenNebula with information about those disks. OpenNebula will scan templates and Wild VMs for existing disks and it will create OpenNebula images that will represent those virtual disks. Thanks to this scanning process, existing disks will be visible for OpenNebula, and therefore can be detached from the deployed VMs. The following information is important about images created when a vCenter template or Wild VM is imported:

- The disks are considered unmanaged images.
- An unmanaged image won’t be cloned by OpenNebula when a VM is instantiated. When OpenNebula deploys a VM, vCenter will clone the vCenter template and it will be responsible of creating the copies of the template disks and attach them to the new Virtual Machine.
- Although the images are considered unmanaged, you can perform operations like detaching the disks.
- Virtual Machines in vCenter will have some variables created by OpenNebula that allows an OpenNebula disk element to be related with a vCenter Virtual Hard Disk. For example the unmanaged DISK with ID=0 has a variable called opennebula.disk.0 in vCenter’s VM that stores a reference to the disk created by vCenter that will help OpenNebula identify what disk has to be detached.
- The VCENTER_IMPORTED attribute is set to YES in the Image template for prevent accidental deletions.
- Although these images represents files that already exists in the datastores, OpenNebula accounts the size of those imported images as if they were new created files hence the datastore capacity is decreased even though no real space in the vCenter datastore is being used by the OpenNebula images. You should understand this limitation if for example an image cannot be imported as OpenNebula reports that no more space is left or if you’re using disk quotas.
- The images that have been imported will have a name generated by OpenNebula. That name contains the name of the VMDK file, the datastore name and the OpenNebula template that is related with that image.

There are three ways of adding VMDK representations in OpenNebula:

- Upload a new VMDK from the local filesystem
- Register an existent VMDK image already in the datastore
- Create a new empty datablock

The following image template attributes need to be considered for vCenter VMDK image representation in OpenNebula:
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PATH</td>
<td>This can be either:</td>
</tr>
<tr>
<td></td>
<td>• local filesystem path to a VMDK to be uploaded, which can be a single VMDK or tar.gz of vmdk descriptor and flat files (no OVAs supported). If using a tar.gz file which contains the flat and descriptor files, both files must live in the first level of the archived file as folders and subfolders are not supported inside the tar.gz file, otherwise a “Could not find vmdk” error message would show up.</td>
</tr>
<tr>
<td></td>
<td>• path of an existing VMDK file in the vCenter datastore or HTTP url. In this case a “vcenter://” prefix must be used (for instance, an image win10.vmdk in a Windows folder should be set to vcenter://Windows/win10.vmdk)</td>
</tr>
<tr>
<td>VCENTER_ADAPTER_TYPE</td>
<td>Default adapter type used by virtual disks to plug inherited to VMs for the images in the datastore. It is inherited by images and can be overwritten if specified explicitly in the image. Possible values (careful with the case): lsiLogic, ide, busLogic. More information in the VMware documentation. Known as “Bus adapter controller” in Sunstone.</td>
</tr>
<tr>
<td>VCENTER_DISK_TYPE</td>
<td>The type of disk has implications on performance and occupied space. Values (careful with the case): delta,eagerZeroedThick,flatMonolithic,preallocated,raw,rdmp,rdms,rdm,sparse,sparse2Gb,sparseMonolithic,thick,thick2Gb,thin. More information in the VMware documentation. Known as “Disk Provisioning Type” in Sunstone.</td>
</tr>
<tr>
<td>VCENTER_IMPORTED</td>
<td>It will be set to YES for images that have been imported when a vCenter template or Wild VM is imported. If this attribute is set to YES, OpenNebula will not delete the VMDK file in vCenter so you don’t actually delete the hard disk attached to a template. If you remove this attribute the VMDK file will be deleted when the Image is deleted in OpenNebula.</td>
</tr>
</tbody>
</table>

VMDK images in vCenter datastores can be:

- Cloned
- Deleted
- Hotplugged to VMs

Images can be imported from the vCenter datastore using the onevcenter tool.
5.1 Overview

OpenNebula uses a method called contextualization to send information to the VM at boot time. Its most basic usage is to share networking configuration and login credentials with the VM so it can be configured. More advanced cases can be starting a custom script on VM boot or preparing configuration to use OpenNebula Gate.

5.1.1 How Should I Read This Chapter

Before reading this chapter, you should have already installed your Frontend, the KVM Hosts, LXD Hosts or vCenter node and have an OpenNebula cloud up and running with at least one virtualization node.

To enable the use of contextualization there are two steps that you need to perform:

- Installing contextualization packages in your images
- Set contextualization data in the VM template

Learn how to do that in the contextualization guide linked below for the hypervisor configured.

5.1.2 Hypervisor Compatibility

<table>
<thead>
<tr>
<th>Section</th>
<th>Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Cloud Contextualization</td>
<td>This Section applies to KVM and LXD.</td>
</tr>
<tr>
<td>vCenter Contextualization</td>
<td>This Section applies to vCenter.</td>
</tr>
<tr>
<td>Adding Content to your Cloud</td>
<td>This Section applies to all hypervisors.</td>
</tr>
</tbody>
</table>

5.2 Open Cloud Contextualization

5.2.1 Prepare the Virtual Machine Image

Step 1. Start a VM with the OS you want to Customize

Supported contextualization packages are available for the OS’s described in the platform notes.
Step 2. Download Contextualization Packages to the VM

**CentOS/RHEL 6.x**

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context-5.10.0-1.el6.noarch.rpm

**CentOS/RHEL 7.x**

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context-5.10.0-1.el7.noarch.rpm

**CentOS/RHEL 8.x and Fedora 29+**

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context-5.10.0-1.el8.noarch.rpm

**OpenSUSE 42,15 / SLES 12**

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context-5.10.0-1.suse.noarch.rpm

**Debian/Ubuntu/Devuan**

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context_5.10.0-1.deb

**Alpine Linux**

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context-5.10.0-r1.apk

**FreeBSD 11,12**

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context-5.10.0_1.txz

**Windows**

Download the MSI package into C:\:

- https://github.com/OpenNebula/addon-context-windows/releases/download/v5.10.0/one-context-5.10.0.msi

Or execute this command in powershell:

```powershell
```

Step 3. Install Contextualization Packages and Dependencies

**CentOS/RHEL 6**

# yum install -y epel-release
# yum install -y one-context-\{0-9\}*el6*rpm
CentOS/RHEL 7

# yum install -y epel-release
# yum install -y one-context-[0-9]*el7.rpm

CentOS/RHEL 8 and Fedora 29+

# yum install -y epel-release
# yum install -y one-context-[0-9]*el8.rpm

OpenSUSE

# zypper --no-gpg-check install -y one-context-[0-9]*suse.rpm

Debian/Ubuntu/Devuan

# apt-get purge -y cloud-init
# dpkg -i one-context_*deb || apt-get install -fy

Alpine Linux

# apk add --allow-untrusted one-context-[0-9]*apk

FreeBSD

# pkg install -y curl bash sudo base64 ruby open-vm-tools-nox11
# pkg install -y one-context-[0-9]*.txz

Windows

Double-click on the downloaded MSI package icon in the same way you open other documents to install it.

Step 4. Run Sysprep in Windows Machines

Execute `sysprep` to prepare the OS for duplication. You can find more information at:

Step 5. Power Off the Machine and Save it

After these configuration is done you should power off the machine, so it is in a consistent state the next time it boots. Then you will have to save the image.

If you are using OpenNebula to prepare the image you can use the command `onevm disk-saveas`, for example, to save the first disk of a Virtual Machine called “centos-installation” into an image called “centos-contextualized” you can issue this command:
Using sunstone web interface you can find the option in the Virtual Machine storage tab.

**5.2.2 Set Up the Virtual Machine Template**

The Virtual Machine Template has a section called context where you can automate different configuration aspects. The most common attributes are network configuration, user credentials and startup scripts. These parameters can be both added using the CLI to the template or using Sunstone Template wizard. Here is an example of the context section using the CLI:

```plaintext
CONTEXT = {
    TOKEN = "YES",
    NETWORK = "YES",
    SSH_PUBLIC_KEY = "$USER[SSH_PUBLIC_KEY]",
    START_SCRIPT = "yum install -y ntpdate"
}
```

In the example we are telling OpenNebula to:

- Set OneGate token and onegate information in the context
- Add network configuration to the Virtual Machine
- Enable login into the Virtual Machine using ssh with the value of the user’s parameter `SSH_PUBLIC_KEY`
- On Virtual Machine boot execute the command `yum install -y ntpdate`

**OneGate Token**

OpenNebula has a centralized service to share data between Virtual Machines and the main daemon, useful to set monitoring information that can be gathered inside the VM and configuration data. It also lets you send scaling actions when the Virtual Machine belongs to a Service.

To do so the client installed with the contextualization packages (`onegate`) needs some information:

- **Token**: it’s the key specific to each VM used to authenticate with the service
- **OneGate endpoint**: the address where the OneGate daemon is reachable

To fill this information you have to specify `TOKEN = "YES"` in the contextualization section.

**Network Configuration**

OpenNebula does not rely on a DHCP server to configure networking in the Virtual Machines. To do this configuration it injects the network information in the contextualization section. This is done with option `NETWORK = "YES"`. When OpenNebula finds this option it adds the IP information for each of the network interfaces configured plus extra information that resides in the Virtual Network template, like DNS, gateway and network mask.

The parameters used from the Virtual Network template are explained in the *Managing Virtual Networks section*.

**User Credentials**

One of the other very important things you have to configure is user credentials to connect to the newly created Virtual Machine. For linux base images we recommend to use SSH public key authentication and using it with OpenNebula is very convenient.
The first thing the users should do is to add their SSH public key (or keys) to its OpenNebula user configuration. This can be done in the Settings section of the web interface or using the command line interface:

$ oneuser update myusername
# an editor is opened, add this line
SSH_PUBLIC_KEY="ssh-rsa MYPUBLICKEY..."

Then in the Virtual Machine Template we add the option:

```plaintext
CONTEXT = [
    SSH_PUBLIC_KEY = "$USER[SSH_PUBLIC_KEY]"
]
```

Using this system the new Virtual Machines will be configured with the SSH public key of the user that instantiated it.

For Windows machines SSH is not available but you can use the options USERNAME and PASSWORD to create and set the password of an initial administrator.

```plaintext
CONTEXT = [
    USERNAME = "Administrator",
    PASSWORD = "VeryComplexPassw0rd"
]
```

**Execute Scripts on Boot**

To be able to execute commands on boot, for example, to install some software, you can use the option START_SCRIPT. When this option is used a new file that contains the value of the option will be created and executed.

For Windows machines this is a PowerShell script. For linux machines this can be any scripting language as long as it is installed in the base image and the proper shebang line is set (shell scripts don’t need shebang).

In this example some commands will be executed using bash shell that will install the package ntpdate and set the time.

```plaintext
CONTEXT = [
    START_SCRIPT = "#!/bin/bash
    yum update
    yum install -y ntpdate
    ntpdate 0.pool.ntp.org"
]
```

To add more complex scripts you can also use the option START_SCRIPT_BASE64. This option gets a base64 encoded string that will be decoded before writing the temporary script file.

**Advanced Contextualization**

There are more options that can be set in the contextualization section. You can read about them in the Virtual Machine Definition File reference section

### 5.3 vCenter Contextualization and Customization

In OpenNebula you have two options if you want to prepare the guest OS on boot:

- *OpenNebula’s contextualization.*
5.4 vCenter Contextualization

OpenNebula uses a method called contextualization to send information to the VM at boot time. Its most basic usage is to share networking configuration and login credentials with the VM so it can be configured.

5.4.1 Prepare the Virtual Machine Image

Step 1. Start a VM with the OS you want to Customize

Supported contextualization packages are available for the OS’s described in the platform notes. If you already happen to have a VM or Template in vCenter with the installed OS you can start it and prepare it to be used with OpenNebula. Alternatively you can start an installation process with the OS media.

Step 2. Download Contextualization Packages to the VM

CentOS/RHEL 6.x

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context-5.10.0-1.el6.noarch.rpm

CentOS/RHEL 7.x

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context-5.10.0-1.el7.noarch.rpm

CentOS/RHEL 8.x and Fedora 29+

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context-5.10.0-1.el8.noarch.rpm

OpenSUSE 42,15 / SLES 12

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context-5.10.0-1.suse.noarch.rpm

Debian/Ubuntu/Devuan

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context_5.10.0-1.deb

Alpine Linux

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context-5.10.0-r1.apk

FreeBSD 11,12

# wget https://github.com/OpenNebula/addon-context-linux/releases/download/v5.10.0/one-context-5.10.0_1.txz
Windows

Download the MSI package into C:\:

- https://github.com/OpenNebula/addon-context-windows/releases/download/v5.10.0/one-context-5.10.0.msi

Or execute this command in powershell:


Step 3. Install Contextualization Packages and Dependencies

CentOS/RHEL 6

# yum install -y epel-release
# yum install -y one-context-[0-9]*el6*rpm

CentOS/RHEL 7

# yum install -y epel-release
# yum install -y one-context-[0-9]*el7*rpm

CentOS/RHEL 8 and Fedora 29+

# yum install -y epel-release
# yum install -y one-context-[0-9]*el8*rpm

OpenSUSE

# zypper --no-gpg-check install -y one-context-[0-9]*suse*rpm

Debian/Ubuntu/Devuan

# apt-get purge -y cloud-init
# dpkg -i one-context_*deb || apt-get install -fy

Alpine Linux

# apk add --allow-untrusted one-context-[0-9]*apk

FreeBSD

# pkg install -y curl bash sudo base64 ruby open-vm-tools-nox11
# pkg install -y one-context-[0-9]*.txz

Windows

Double-click on the downloaded MSI package icon in the same way you open other documents to install it.
Step 4. Install VMware Tools

CentOS, Debian/Ubuntu

open-vm-tools are installed as a dependency of contextualization package.

Windows

In vCenter open the VM menu, go to “Guest OS” section, click in “Install VMware Tools…” and follow the instructions.

Step 5. Run Sysprep in Windows Machines

Execute sysprep to prepare the OS for duplication. You can find more information at:

Step 6. Power Off the Machine and Save it

These are the steps needed to finish the preparation and import it to OpenNebula:

- Power off the machine so it is in a consistent state the next time it boots.
- Make sure that you take out any installation media used in the previous steps.
- Convert the VM into a Template following this procedure
- Import in OpenNebula, the datastores where the template’s virtual hard disks are located.
- Import the template in OpenNebula.

The last two steps can be done using Sunstone or the CLI as explained in the Import vCenter Resources section

5.4.2 Set Up the Virtual Machine Template

The Virtual Machine Template has a section called context where you can automate different configuration aspects. The most common attributes are network configuration, user credentials and startup scripts. These parameters can be both added using the CLI to the template or using Sunstone Template wizard. Here is an example of the context section using the CLI:

```
CONTEXT = {
    TOKEN = "YES",
    NETWORK = "YES",
    SSH_PUBLIC_KEY = "$USER[SSH_PUBLIC_KEY]",
    START_SCRIPT = "yum install -y ntpdate"
}
```

In the example we are telling OpenNebula to:

- Set OneGate token and onegate information in the context
- Add network configuration to the Virtual Machine
- Enable login into the Virtual Machine using ssh with the value of the user’s parameter SSH_PUBLIC_KEY
- On Virtual Machine boot execute the command yum install -y ntpdate
OneGate Token

OpenNebula has a centralized service to share data between Virtual Machines and the main daemon, useful to set monitoring information that can be gathered inside the VM and configuration data. It also lets you send scaling actions when the Virtual Machine belongs to a Service.

To do so the client installed with the contextualization packages (onegate) needs some information:

- **Token**: it’s the key specific to each VM used to authenticate with the service
- **OneGate endpoint**: the address where the OneGate daemon is reachable

To fill this information you have to specify `TOKEN = "YES"` in the contextualization section.

Network Configuration

OpenNebula does not rely on a DHCP server to configure networking in the Virtual Machines. To do this configuration it injects the network information in the contextualization section. This is done with option `NETWORK = "YES"`. When OpenNebula finds this option it adds the IP information for each of the network interfaces configured plus extra information that resides in the Virtual Network template, like DNS, gateway and network mask.

The parameters used from the Virtual Network template are explained in the *Managing Virtual Networks section*.

User Credentials

One of the other very important things you have to configure is user credentials to connect to the newly created Virtual Machine. For linux base images we recommend to use SSH public key authentication and using it with OpenNebula is very convenient.

The first thing the users should do is to add their SSH public key (or keys) to its OpenNebula user configuration. This can be done in the Settings section of the web interface or using the command line interface:

```bash
$ oneuser update myusername
# an editor is opened, add this line
SSH_PUBLIC_KEY="ssh-rsa MYPUBLICKEY..."
```

Then in the Virtual Machine Template we add the option:

```yaml
CONTEXT = [
  SSH_PUBLIC_KEY = "$USER[SSH_PUBLIC_KEY]"
]
```

Using this system the new Virtual Machines will be configured with the SSH public key of the user that instantiated it.

For Windows machines SSH is not available but you can use the options `USERNAME` and `PASSWORD` to create and set the password of an initial administrator.

```yaml
CONTEXT = [
  USERNAME = "Administrator",
  PASSWORD = "VeryComplexPassw0rd"
]
```

Execute Scripts on Boot

To be able to execute commands on boot, for example, to install some software, you can use the option `START_SCRIPT`. When this option is used a new file that contains the value of the option will be created and executed.
For Windows machines this is a PowerShell script. For Linux machines this can be any scripting language as long as it is installed in the base image and the proper shebang line is set (shell scripts don’t need shebang).

In this example some commands will be executed using bash shell that will install the package ntpdate and set the time.

```
CONTEXT = [
    START_SCRIPT = "#!/bin/bash
    yum update
    yum install -y ntpdate
    ntpdate 0.pool.ntp.org"
]
```

To add more complex scripts you can also use the option START_SCRIPT_BASE64. This option gets a base64 encoded string that will be decoded before writing the temporary script file.

**Advanced Contextualization**

There are more options that can be set in the contextualization section. You can read about them in the Virtual Machine Definition File reference section.

### 5.4.3 vCenter Customization

vCenter offers a way to prepare the guest OS on boot. For example configuring its network, licenses, Active Directory server, etc. OpenNebula vCenter drivers offers a way to tie one OpenNebula template with one of these customizations so it is applied on VM startup. You can get more information about this system in VMware documentation.

There are a couple of things to take into account:

- It only works with OpenNebula vcenter driver.
- This system is not compatible with OpenNebula contextualization as this customization overwrites the networking changes made by context scripts.
- VM network configuration must be done externally to OpenNebula. Either with a DHCP server or manually setting IPs for each interface.
- This method can be used in all the Guest OSs supported by vCenter.

**Applying Customization to one Template Using Sunstone**

For vcenter templates there are two options in the context tab. To use vCenter Customization select “vCenter” in the as “Contextualization type”. This will show a dropdown with all the customizations from all the hosts. There you can select from these possibilities:

- **None**: No customization will be applied
- **Custom**: You will be able to type manually the name of one customization
- **The name of customizations found in vCenters**
Make sure that the customization applied is available in the vCenter where the VM template reside.

Once we update the template, we’ll get a VCENTER_CUSTOMIZATION_SPEC attribute inside the USER_TEMPLATE section.

```yaml
USER TEMPLATE = [
    VCENTER_CUSTOMIZATION_SPEC = "LinuxCustomization"
]
```

### Getting the Available Customizations per Cluster

OpenNebula monitoring probes get the list of available customization specifications per cluster. You can get the list with the command `onehost show`. Look for CUSTOMIZATION data in MONITORING INFORMATION. For example:

```bash
$ onehost show 20

[...]
MONITORING INFORMATION
...
CUSTOMIZATION=[
    NAME="linux-customization",
    TYPE="Linux"
] CUSTOMIZATION=[
    NAME="custom",
    TYPE="Windows"
]
```

### Applying Customization to a template Using CLI

To add a customization specification to one template a parameter called VCENTER_CUSTOMIZATION_SPEC must be added inside the USER_TEMPLATE section. Take for example this template:

```plaintext
CPU = "1"
DESCRIPTION = "vCenter Template imported by OpenNebula from Cluster Cluster"
DISK = [
    IMAGE_ID = "124",
    IMAGE_UNAME = "oneadmin",
    OPENNEBULA_MANAGED = "NO"
] GRAPHICS = [
    LISTEN = "0.0.0.0",
    TYPE = "VNC"
] HYPERVISOR = "vcenter"
LOGO = "images/logos/linux.png"
MEMORY = "256"
NIC = [
    NETWORK_ID = "61",
    OPENNEBULA_MANAGED = "NO"
] OS = [
    BOOT = ""
] SCHER_REQUIREMENTS = "ID="20"
VCENTER_CCR_REF = "domain-c14"
VCENTER_INSTANCE_ID = "4946bb10-e8dc-4574-ac25-3841bcf189b9"
VCENTER_RESOURCE_POOL = "Dev6ResourcePool/nested/tino"
VCENTER_TEMPLATE_REF = "vm-2353"
VCENTER_VM_FOLDER = ""
VCPU = "1"
```
5.5 Adding Content to Your Cloud

Once you have setup your OpenNebula cloud you’ll have ready the infrastructure (clusters, hosts, virtual networks and datastores) but you need to add contents to it for your users. This basically means two different things:

- Add base disk images with OS installations of your choice. Including any software package of interest.
- Define virtual servers in the form of VM Templates. We recommend that VM definitions are made by the admins as it may require fine or advanced tuning. For example you may want to define a LAMP server with the capacity to be instantiated in a remote AWS cloud.

When you have basic virtual server definitions the users of your cloud can use them to easily provision VMs, adjusting basic parameters, like capacity or network connectivity.

There are three basic methods to bootstrap the contents of your cloud, namely:

- **External Images.** If you already have disk images in any supported format (raw, qcow2, vmdk...) you can just add them to a datastore. Alternatively you can use any virtualization tool (e.g. virt-manager) to install an image and then add it to a OpenNebula datastore.
- **Install within OpenNebula.** You can also use OpenNebula to prepare the images for your cloud.
- **Use the OpenNebula Marketplace.** Go to the marketplace tab in Sunstone, and simply pick a disk image with the OS and Hypervisor of your choice.

Once the images are ready, just create VM templates with the relevant configuration attributes, including default capacity, networking or any other preset needed by your infrastructure.

You are done, make sure that your cloud users can access the images and templates you have just created.
5.5.1 Adding External Images

You can use as basis for your images the ones provided by the distributions. These images are usually prepared to be used with other clouds and won’t behave correctly or will not have all the features provided by OpenNebula. You can do a customization of these images before importing them.

To do this modification we are going to use the software libguestfs in a Linux machine with kvm support. You should use a modern distribution to have a recent version of libguestfs (>= 1.26). To have the latest version you can use Arch Linux but a CentOS 7 is OK.

Step 1. Install Libguestfs

The package is available in most distributions. Here are the commands to do it in some of them.

**CentOS**

```bash
# yum install libguestfs-tools
```

**Debian/Ubuntu**

```bash
# apt-get install libguestfs-tools
```

**Arch Linux**

This package is available in aur repository. You can either download the PKGBUILD and compile it manually or use a pacman helper like yaourt:

```bash
# yaourt -S libguestfs
```

Step 2. Download the Image

You can find the images for distributions in these links. We are going to use the ones from CentOS but the others are here for reference:

- **CentOS 7**: [http://cloud.centos.org/centos/7/images/](http://cloud.centos.org/centos/7/images/)
- **Debian**: [http://cdimage.debian.org/cdimage/openstack/](http://cdimage.debian.org/cdimage/openstack/)
- **Ubuntu**: [https://cloud-images.ubuntu.com/](https://cloud-images.ubuntu.com/)

Step 3. Download Context Packages

The context packages can be downloaded from the release section of the project. Make sure you download the version you need. For example, for CentOS download the rpm version. Also, don’t download the packages marked with ec2 as they are specific for EC2 images.

You have to download them to a directory that we will later refer. In this example it’s going to be called packages.
Step 4. Create a CDROM Image with Context Packages

We will use this image as the source to install the context package. The image will be created with a specific label so later is easier to mount it. The label chosen is PACKAGES.

```bash
$ genisoimage -o packages.iso -R -J -V PACKAGES packages/
```

Step 5. Create a Script to Prepare the Image

The script will be different depending on the distribution and any extra steps we want to do to the image. The script will be executed in a chroot of the image root filesystem.

Here are some versions of the script for several distributions. The script will be called script.sh.

**CentOS 6**

```bash
mkdir /tmp/mount
mount LABEL=PACKAGES /tmp/mount

yum install -y epel-release

# Remove NetworkManager
yum remove -y NetworkManager

# Upgrade util-linux
yum upgrade -y util-linux

# Install OpenNebula context package
yum install -y /tmp/mount/one-context*el6*rpm

# Take out the serial console from kernel configuration
# (it can freeze during the boot process).
sed -i --follow-symlinks '/^serial/d' /etc/grub.conf
sed -i --follow-symlinks 's/\s/console=ttyS\[\([^]\)+\]+\)/g' /etc/grub.conf
```
**CentOS 7**

```
mkdir /tmp/mount
mount LABEL=PACKAGES /tmp/mount

yum install -y epel-release

# Remove NetworkManager
yum remove -y NetworkManager

# Install OpenNebula context package
yum install -y /tmp/mount/one-context*el7.rpm

# Take out serial console from kernel configuration
# (it can freeze during the boot process).
sed -i --follow-symlinks 's/console=ttyS[^ "]*//g' /etc/default/grub /etc/grub2.cfg
```
Ubuntu 14.04, 16.04

```bash
# mount cdrom with packages
mkdir /tmp/mount
mount LABEL=PACKAGES /tmp/mount
apt-key update
apt-get update

# Remove cloud-init
apt-get remove -y cloud-init

# Install OpenNebula context package
dpkg -i /tmp/mount/one-context*deb || apt-get install -fy

# Take out serial console from kernel configuration
# (it can freeze during the boot process).
sed -i 's/console=ttyS[^ "]*/' /etc/default/grub /boot/grub/grub.cfg
```

**Step 6. Create an Overlay Image**

It’s always a good idea to not modify the original image in case you want to use it again or something goes wrong with the process. To do it we can use `qemu-img` command:

```bash
$ qemu-img create -f qcow2 -b <original image> modified.qcow2
```

**Step 7. Apply Customizations to the Image**

Now we are going to execute `virt-customize` (a tool of libguestfs) to modify the image. This is the meaning of the parameters:

- `-v`: verbose output, in case we want to debug problems
- `--attach packages.iso`: add the CDROM image previously created with the packages
- `--format qcow2`: the image format is qcow2
- `--a modified.qcow2`: the disk image we want to modify
- `--run script.sh`: script with the instructions to modify the image

```bash
$ virt-customize -v --attach packages.iso --format qcow2 -a modified.qcow2 --run --script.sh --root-password disabled
```
Step 8. Convert the Image to the Desired Format

After we are happy with the result we can convert the image to the preferred format to import to OpenNebula. Even if we want a qcow2 image we have to convert it to consolidate all the layers in one file. For example, to create a qcow2 image that can be imported to fs (ssh, shared and qcow2), ceph and fs_lvm datastores we can execute this command:

```bash
$ qemu-img convert -O qcow2 modified.qcow2 final.qcow2
```

To create a vmdk image, for vCenter hypervisors we can use this other command:

```bash
$ qemu-img convert -O vmdk modified.qcow2 final.vmdk
```

Step 9. Upload it to an OpenNebula Datastore

You can now use Sunstone to upload the final version of the image or copy it to the frontend and import it. If you are going to use the second option make sure that the image is in a directory that allows image imports (by default /var/tmp). For example:

```bash
$ oneimage create --name centos7 --path /var/tmp/final.qcow2 --driver qcow2 --prefix vd --datastore default
```

5.5.2 Install within OpenNebula

If you are using KVM hypervisor you can do the installations using OpenNebula. Here are the steps to do it:

Step 1. Add the Installation Medium

You can add the installation CD to OpenNebula uploading the image using Sunstone and setting its type to CDROM or using the command line. For example, to add the CentOS ISO file you can use this command:

```bash
$ oneimage create --name centos7-install --path http://buildlogs.centos.org/rolling/7/isos/x86_64/CentOS-7-x86_64-DVD.iso --type CDROM --datastore default
```

Step 2. Create Installation Disk

The disk where the OS will be installed needs to be created as a DATABLOCK. Don’t make the image too big as it can be resized afterwards on VM instantiation. Also make sure to make it persistent so we don’t lose the installation when the Virtual Machine terminates.
If you are using the CLI you can do the same with this command:

```
$ oneimage create --name centos7 --description "Base CentOS 7 Installation" --type,DATABLOCK --persistent --prefix vd --driver qcow2 --size 10240 --datastore default
```

**Step 3. Create a Template to do the Installation**

In this step you have to take the following into account:

- Add first the persistent datablock and second the installation media in the storage tab
- Add a network as it will be needed to download context packages
- On OS Booting tab enable both disks for booting. The first time it will use the CD and after installing the OS the DATABLOCK will be used
- In Input/Output tab enable VNC and add as input an USB Tablet. This will be useful in case the OS has a graphical installation

This can be done with the CLI using this command:

```
$ onetemplate create --name centos7-cli --cpu 1 --memory 1G --disk centos7,centos7-install --nic network --boot disk0,disk1 --vnc --raw "INPUT=[TYPE=tablet,BUS=usb]"
```
Now instantiate the template and do the installation using the VNC viewer. Make sure that you configure the network manually as there are no context packages in the installation media. Upon completion tell the instanter to reboot the machine, log into the new OS and follow the instructions from the accompanying sections to install the contextualization.

As a tip, one of the latest things you should do when using this method is disabling root password and deleting any extra users that the install tool has created.

**Step 4. Shutdown the Machine and Configure the Image**

You can now shutdown the Virtual Machine from inside, that is, use the OS to shutdown itself. When the machine appears as poweroff in OpenNebula terminate it.

Make sure that you change the image to non persistent and you give access to other people.

Using the CLI you can do:

```
$ oneimage nonpersistent centos7
$ oneimage chmod centos7 744
```

### 5.5.3 Use the OpenNebula Marketplace

If your frontend is connected to the internet it should have access to the public OpenNebula Marketplace. In it there are several images prepared to run in an OpenNebula Cloud. To get images from it you can go to the Storage/Apps tab in Sunstone web interface, select one of the images and click the button “<arrow> OpenNebula”:

Using the CLI we can list an import using these commands:

```
$ onemarketapp list

<table>
<thead>
<tr>
<th>ID</th>
<th>NAME</th>
<th>VERSION</th>
<th>SIZE</th>
<th>STAT</th>
<th>TYPE</th>
<th>REGTIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>boot2docker</td>
<td>1.10.2</td>
<td>32M</td>
<td>rdy</td>
<td>img</td>
<td>02/26/16</td>
</tr>
</tbody>
</table>
```

### 5.5. Adding Content to Your Cloud
5.5.4 How to Prepare the Service Templates

When you prepare a OneFlow Service Template to be used by the Cloud View users, take into account the following:

- You can define dynamic networks in the Service Template, to allow users to choose the virtual networks for the new Service instance.

- If any of the Virtual Machine Templates used by the Roles has User Inputs defined (see the section above), the user will be also asked to fill them when the Service Template is instantiated.

- Users will also have the option to change the Role cardinality before the Service is created.
Network

Private network for the service traffic

**INTERFACE**  **devs-private**

Network with access to public IPs

**Select a Network for this interface**

- **devs-private**
  - Private network for the devs group

- **public**
  - Network with connectivity to the internet
To make a Service Template available to other users, you have two options:

- Change the Template’s group, and give it GROUP USE permissions. This will make the Service Template only available to users in that group.

- Leave the Template in the oneadmin group, and give it OTHER USE permissions. This will make the Service Template available to every user in OpenNebula.

Please note that you will need to do the same for any VM Template used by the Roles, and any Image and Virtual Network referenced by those VM Templates, otherwise the Service deployment will fail.
6.1 Overview

This chapter contains reference guides for Sunstone end-users.

6.1.1 How Should I Read This Chapter

The following sections are intended for the cloud consumers. They can skip most of the OpenNebula documentation and read these two guides only.

Proceed to the corresponding guide following these links:

- *Self-service Cloud View*: For cloud consumers that just require a portal where they can provision new virtual machines and services easily.
- *Group Admin View*: For group administrators. This view allows the management of the group’s resources, including the creation of new users.

6.1.2 Hypervisor Compatibility

Sunstone is available for all the hypervisors. When using vCenter, the cloud admin should enable the `groupadmin_vcenter` and `cloud_vcenter` Sunstone views.

6.2 Self-service Cloud View

This is a simplified view intended for cloud consumers that just require a portal where they can provision new virtual machines easily. To create new VMs and Services, they just have to select one of the available templates prepared by the administrators.
6.2.1 Using the Cloud

Create VM

In this scenario the cloud administrator must prepare a set of templates and images and make them available to the cloud users. These Templates must be ready to be instantiated, i.e. they define all the mandatory attributes. Before using them, users can optionally customize the VM capacity, resize disks, add new network interfaces and provide values required by the template. Read *Adding Content to Your Cloud* for more information.
Access the VMs with SSH Keys

Any user can provide his own ssh public key to be included in the VMs created through this view. Note that the template has to be configured to include it.
Add a public SSH key to your account!
You will be able to access your Virtual Machines without password

SSH key

Add SSH Key

Manage VMs

The status of the VMs can be monitored from the VMs tab.
Information about the capacity, OS, IPs, creation time and monitoring graphs for a specific VM are available in the detailed view of the VM.

A user can perform the following actions from this view:

- Access the VNC console, note that the Template has to be configured for this
- Reboot the VM, the user can send the reboot signal (reboot) or reboot the machine (reboot hard)
- Power off the VM, the user can send the power off signal (poweroff) or power off the machine (poweroff hard)
- Terminate the VM
- Save the VM into a new Template
- Power on the VM

**Make the VM Changes Persistent**

Users can create a persistent private copy of the available templates. A persistent copy will preserve the changes made to the VM disks after the instance is terminated. This template is private, and will only be listed to the owner user.

To create a persistent copy, use the “Persistent” switch next to the create button:
Alternatively, a VM that was not created as persistent can be saved before it is destroyed. To do so, the user has to power off the VM first and then use the save operation.
Any of these two actions will create a new Template with the VM name. This template can be used in the “new VM wizard” to restore the VM after it is terminated. This template contains a copy of each one of the original disk images. If you delete this template, all the disk contents will be also lost.
Note: Avoid making a persistent copy of a persistent copy! Although there are use cases where it is justified, you will end with a long list of Templates and the disk usage quota will decrease quickly.

For more details about the limitations of saved VM, continue to the Managing Virtual Machines guide.

Create Service

In this scenario the cloud administrator must prepare a set of Service templates and make them available to the cloud users. These Service templates must be ready to be instantiated, i.e. they define all the mandatory attributes and the templates that are referenced are available for the user. Before using them, users can optionally customize the Service cardinality, define the network interfaces and provide values required by the template. Read Adding Content to Your Cloud for more information.

Manage Services

The status of the Services can be monitored from the Services tab
Information of the creation time, cardinality and status for each Role are available in the detailed view of the Service.

A user can perform the following actions from this view:

- Change the cardinality of each Role
- Retrieve the VMs of each Role
- Delete the Service
- Recover the Service from a fail status

**Usage, Accounting and Showback**

The user can check his current usage and quotas
Also, the user can generate accounting reports for a given range of time
6.2. Self-service Cloud View

[Image of a self-service cloud view dashboard with charts showing CPU and Memory GB hours for the period from 2014/8/3 to 2014/8/5.]
User Settings

From the user settings tab, the user can change his password, language, ssh key and view
6.3 Group Admin View

The role of a Group Admin is to manage all the virtual resources of the Group, including the creation of new users. When one of these Group Admin users access Sunstone, they get a limited version of the cloud administrator view. You can read more about OpenNebula’s approach to Groups and VDC’s from the perspective of different user roles in the Understanding OpenNebula guide.

Group administrators can also access the simplified Cloud View if they prefer to.
6.3.1 Manage Users

The Group Admin can create new user accounts, that will belong to the same Group.
They can also see the current resource usage of all the Group users, and set quota limits for each one of them.
6.3.2 Manage Resources

The Group admin can manage the Services, VMs and Templates of other users in the Group.
6.3.3 Create Resources

The Group admin can create new resources in the same way as a regular user does from the Cloud view. The creation wizard for the Virtual Machines and Services are similar in the groupadmin and cloud views.
6.3.4 Prepare Resources for Other Users

Any user of the Cloud View or Group Admin View can save the changes made to a VM back to a new Template, and use this Template to instantiate new VMs later. See the **VM persistency options in the Cloud View** for more information.

The Group admin can also share his own Saved Templates with the rest of the group. For example the Group admin can instantiate a clean VM prepared by the cloud administrator, install software needed by other users in his Group, save it in a new Template and make it available for the rest of the group.

These shared templates will be listed to all the group users in the VM creation wizard, marked as ‘group’. A Saved Template created by a regular user is only available for that user and is marked as ‘mine’.
6.3.5 Accounting & Showback

Group Accounting & Showback

The Group info tab provides information of the usage of the Group and also accounting and showback reports can be generated. These reports can be configured to report the usage per VM or per user for a specific range of time.
6.3. Group Admin View
User Accounting & Showback

The detailed view of the user provides information of the usage of the user, from this view accounting reports can be also generated for this specific user.
6.3.6 Networking

Group administrators can create Virtual Routers from Templates prepared by the cloud administrator. These Virtual Routers can be used to connect two or more of the Virtual Networks assigned to the Group.
7.1 Overview

Every resource in OpenNebula has its own Template, a collection of attributes that modify its behavior and their relationship with other cloud components. This Chapter contains an exhaustive reference of the templates of various resources.

7.1.1 How Should I Read This Chapter

After reviewing and understanding the contents of the operation guide pertinent to your particular cloud infrastructure, you can use this reference Sections to look for the meaning of particular attributes that may be interesting to fine tune the behavior of different resources.

Within this Chapter, you can find references for the templates of images, templates and virtual networks. Also you can find references to all the commands of the command line interface, and a state machine describing all the VM life-cycle states.

You probably be coming back to these Chapter frequently, if you are in the process of deploying and configuring an OpenNebula cloud the next step would be to proceed to the Advanced Components Guide.

7.1.2 Hypervisor Compatibility

All the Sections of this Chapter applies to both KVM and vCenter hypervisors.

7.2 Virtual Machine Definition Template

A template file consists of a set of attributes that defines a Virtual Machine. Using the command onetemplate create, a template can be registered in OpenNebula to be later instantiated. For compatibility with previous versions, you can also create a new Virtual Machine directly from a template file, using the onevm create command.

Warning: There are some template attributes that can compromise the security of the system or the security of other VMs, and can be used only by users in the oneadmin group. These attributes can be configured in oned.conf, the default ones are labeled with * in the following tables. See the complete list in the Restricted Attributes section.

Note: If not explicitly stated, the described attributes are valid for all supported hypervisors.
7.2.1 Syntax

The syntax of the template file is as follows:

- Anything behind the pound or hash sign # is a comment.
- Strings are delimited with double quotes ", if a double quote is part of the string it needs to be escaped \".
- Single Attributes are in the form:

```
NAME=VALUE
```

- Vector Attributes that contain several values can be defined as follows:

```
NAME=[NAME1=VALUE1,NAME2=VALUE2]
```

- Vector Attributes must contain at least one value.
- Attribute names are case insensitive, in fact the names are converted to uppercase internally.

7.2.2 XML Syntax

Template files can be expressed in XML, with the following syntax:

- The root element must be TEMPLATE
- Single Attributes are in the form:

```
<NAME>VALUE</NAME>
```

- Vector Attributes that contain several values can be defined as follows:

```
<NAME>
  <NAME1>VALUE1</NAME1>
  <NAME2>VALUE2</NAME2>
</NAME>
```

A simple example:

```
<TEMPLATE>
  <NAME>test_vm</NAME>
  <CPU>2</CPU>
  <MEMORY>1024</MEMORY>
  <DISK>
    <IMAGE_ID>2</IMAGE_ID>
  </DISK>
  <DISK>
    <IMAGE>Data</IMAGE>
    <IMAGE_UNAME>oneadmin</IMAGE_UNAME>
  </DISK>
</TEMPLATE>
```

7.2.3 Capacity Section

The following attributes can be defined to specify the capacity of a VM.
### Attribute Description

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME</td>
<td>Name that the VM will get for description purposes. If NAME is not supplied a name generated by one will be in the form of one-&lt;VID&gt;. <strong>NOTE:</strong> When defining a Template it is the name of the VM Template. The actual name of the VM will be set when the VM Template is instantiated.</td>
<td>YES For Templates NO For VMs - will be set to one-&lt;vmid&gt; if omitted</td>
</tr>
<tr>
<td>MEMORY</td>
<td>Amount of RAM required for the VM, in Megabytes.</td>
<td>YES</td>
</tr>
<tr>
<td>CPU</td>
<td>Percentage of CPU divided by 100 required for the Virtual Machine, half a processor is written 0.5. This value is used by OpenNebula and the scheduler to guide the host overcommitment.</td>
<td>YES</td>
</tr>
<tr>
<td>VCPU</td>
<td>Number of virtual cpus. This value is optional, the default hypervisor behavior is used, usually one virtual CPU.</td>
<td>YES - will be set to 1 if omitted, this can be changed in the driver configuration</td>
</tr>
</tbody>
</table>

#### Example:

```plaintext
NAME = test-vm
MEMORY = 128
CPU = 1
```

### 7.2.4 Showback Section

The following attributes can be defined to set the cost of a VM. Read the *showback documentation* for more information.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEMORY_COST</td>
<td>Cost of each memory MB per hour.</td>
<td>NO</td>
</tr>
<tr>
<td>CPU_COST</td>
<td>Cost of each CPU per hour.</td>
<td>NO</td>
</tr>
<tr>
<td>DISK_COST</td>
<td>Cost of each disk MB per hour.</td>
<td>NO</td>
</tr>
</tbody>
</table>

### 7.2.5 OS and Boot Options Section

The OS system is defined with the `OS` vector attribute. The following sub-attributes are supported:

**Note** the hypervisor column states that the attribute is Optional, Mandatory, or – not supported for that hypervisor
<table>
<thead>
<tr>
<th>OS Sub-Attribute</th>
<th>Description</th>
<th>KVM</th>
<th>vCenter</th>
<th>LXD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH</td>
<td>CPU architecture to virtualize</td>
<td>M (def-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>fault i686)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MACHINE</td>
<td>libvirt machine type. Check libvirt capabilities for the list of available machine types.</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KERNEL</td>
<td>path to the OS kernel to boot the image in the host</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>KERNEL_DS</td>
<td>image to be used as kernel (see !!)</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>INITRD</td>
<td>path to the initrd image in the host</td>
<td>O (for</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>kernel)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INITRD_DS</td>
<td>image to be used as ramdisk (see !!)</td>
<td>O (for</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>kernel)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROOT</td>
<td>device to be mounted as root</td>
<td>O (for</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>kernel)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KERNEL_CMD</td>
<td>arguments for the booting kernel</td>
<td>O (for</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>kernel)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOOT-LOADER</td>
<td>path to the bootloader executable</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BOOT</td>
<td>comma separated list of boot devices types, by order of preference (first device in the list is the</td>
<td>M</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>first device used for boot). Possible values: disk#_nic#</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD_DISK_BUS</td>
<td>for disks with sd prefix, either scsi or sata, if attribute is missing, libvirt chooses itself</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

(!!) Use one of KERNEL_DS or KERNEL (and INITRD or INITRD_DS).

KERNEL_DS and INITRD_DS refer to and image registered in a File Datastore and must be of type KERNEL and RAMDISK, respectively. The image should be refer using one of the following:

- `$FILE[IMAGE=<image name>]`, to select own files
- `$FILE[IMAGE=<image name>, <IMAGE_UNAME|IMAGE_UID>=<owner name|owner id>]`, to select images owned by other users, by user name or uid.
- `$FILE[IMAGE_ID=<image id>]`, global file selection

Example, a VM booting from sda1 with kernel /vmlinuz:

```python
OS = [ KERNEL = /vmlinuz,
      INITRD = /initrd.img,
      ROOT = sda1,
      KERNEL_CMD = "ro console=tty1"
]
```

```python
OS = [ KERNEL_DS = "$FILE[IMAGE="kernel 3.6"]",
      INITRD_DS = "$FILE[IMAGE="initrd 3.6"]",
      ROOT = sda1,
      KERNEL_CMD = "ro console=tty1"
]
```

### 7.2.6 CPU_MODEL Options Section

This section (CPU_MODEL) configures the hardware configuration of the CPU exposed to the guest.
7.2.7 Features Section

This section configures the features enabled for the VM.

<table>
<thead>
<tr>
<th>Sub-Attribute</th>
<th>Description</th>
<th>KVM</th>
<th>vCenter</th>
<th>LXD</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL</td>
<td>The CPU model exposed to the guest. host-pass through is the same model as the host. Available modes are stored in the host information and obtained through monitor.</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sub-Attribute</th>
<th>Description</th>
<th>KVM</th>
<th>vCenter</th>
<th>LXD</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAE</td>
<td>Physical address extension mode allows 32-bit guests to address more than 4 GB of memory</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ACPI</td>
<td>Useful for power management, for example, with KVM guests it is required for graceful shutdown to work</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>APIC</td>
<td>Enables the advanced programmable IRQ management. Useful for SMP machines.</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LOCAL-TIME</td>
<td>The guest clock will be synchronized to the host’s configured timezone when booted. Useful for Windows VMs</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HYPERV</td>
<td>Add hyperv extensions to the VM. The options can be configured in the driver configuration, HYPERV_OPTIONS</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>GUEST_AGENT</td>
<td>Enables the QEMU Guest Agent communication. This only creates the socket inside the VM, the Guest Agent itself must be installed and started in the VM.</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VIR-TIO_SCSI_QUEUES</td>
<td>Numer of vCPU queues for the virtio-scsi controller.</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

FEATURES = {
    PAE = "yes",
    ACPI = "yes",
    APIC = "no",
    GUEST_AGENT = "yes",
    VIR-TIO_SCSI_QUEUES = "4"
}

7.2.8 Disks Section

The disks of a VM are defined with the DISK vector attribute. You can define as many DISK attributes as you need. There are three types of disks:

- Persistent disks, uses an Image registered in a Datastore mark as persistent.
- Clone disks, uses an Image registered in a Datastore. Changes to the images will be discarded. A clone disk can be saved as other image.
- Volatile disks, created on-the-fly on the target hosts. Disks are disposed when the VM is shutdown and cannot be saved_as
Persistent and Clone Disks

Note the hypervisor column states that the attribute is Optional, Mandatory, or – not supported for that hypervisor.
<table>
<thead>
<tr>
<th>DISK Sub-Attribute</th>
<th>Description</th>
<th>KVM</th>
<th>vCenter</th>
<th>LXD</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMAGE_ID</td>
<td>ID of the Image to use</td>
<td>M (no IMAGE)</td>
<td>M (no IMAGE)</td>
<td>M (no IMAGE)</td>
</tr>
<tr>
<td>IMAGE</td>
<td>Name of the Image to use</td>
<td>M(no IMAGE_ID)</td>
<td>M (no IMAGE_ID)</td>
<td>M (no IMAGE_ID)</td>
</tr>
<tr>
<td>IMAGE_UID</td>
<td>To select the IMAGE of a given user by her ID</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>IMAGE_UNAME</td>
<td>To select the IMAGE of a given user by her NAME</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>DEV_PREFIX</td>
<td>Prefix for the emulated device this image will be mounted at. For instance, attribute of the Image will be used</td>
<td>O</td>
<td>-</td>
<td>O (where to mount the image inside the container e.g.: /mnt. Only applies for non root devices)</td>
</tr>
<tr>
<td>TARGET</td>
<td>Device to map image disk. If set, it will overwrite the default device hd, sd, or vd for KVM virtio. If omitted, the dev_prefix mapping.</td>
<td>O</td>
<td>-</td>
<td>O</td>
</tr>
<tr>
<td>DRIVER</td>
<td>Specific image mapping driver</td>
<td>O e.g.: raw, qcow2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CACHE</td>
<td>Selects the cache mechanism for the disk. Values are default, none, writethrough, writeback, directsync and unsafe. More info in the libvirt documentation</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>READONLY</td>
<td>Set how the image is exposed by the hypervisor</td>
<td>O e.g.: yes, no. This attribute should only be used for special storage configurations</td>
<td>-</td>
<td>O</td>
</tr>
<tr>
<td>IO</td>
<td>Set IO policy. Values are threads, native</td>
<td>O (Needs qemu 1.1)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TOTAL_BYTES_SEC, READ_BYTES_SEC, WRITE_BYTES_SEC TOTAL_IOPS_SEC, READ_IOPS_SEC, WRITE_IOPS_SEC</td>
<td>IO throttling attributes for the disk. They are specified in bytes or IOPS (IO Operations) and can be specified for the total (read+write) or specific for read or write. Total and read or write can not be used at the same time. By default these parameters are only allowed to be used by oneadmin.</td>
<td>O (Needs qemu 1.1)</td>
<td>-</td>
<td>O</td>
</tr>
<tr>
<td>TOTAL_BYTES_SEC_MAX, READ_BYTES_SEC_MAX, WRITE_BYTES_SEC_MAX TOTAL_IOPS_SEC_MAX, READ_IOPS_SEC_MAX, WRITE_IOPS_SEC_MAX</td>
<td>Maximum IO throttling attributes for the disk. They are specified in bytes or IOPS (IO Operations) and can be specified for the total (read+write) or specific for read or write. Total and read or write can not be used at the same time. By default these parameters are only allowed to be used by oneadmin.</td>
<td>O (Needs qemu 1.1)</td>
<td>-</td>
<td>O</td>
</tr>
</tbody>
</table>
Volatile DISKS

**Warning:** Not supported on LXD

<table>
<thead>
<tr>
<th>DISK Sub-Attribute</th>
<th>Description</th>
<th>KVM</th>
<th>vCenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE</td>
<td>Type of the disk: swap or fs. Type swap is not supported in vcenter.</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>SIZE</td>
<td>Size in MB</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>FORMAT</td>
<td>Format of the Image: raw or qcow2.</td>
<td>M(for fs)</td>
<td>M(for fs)</td>
</tr>
<tr>
<td>DEV_PREFIX</td>
<td>Prefix for the emulated device this image will be mounted at. For instance, hd, sd. If omitted, the default dev_prefix set in oned.conf will be used</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>TARGET</td>
<td>Device to map disk</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>DRIVER</td>
<td>Special disk mapping options. KVM: raw, qcow2.</td>
<td>O</td>
<td>-</td>
</tr>
<tr>
<td>CACHE</td>
<td>Selects the cache mechanism for the disk. Values are default, none, writethrough, writeback, directsync and unsafe. More info in the libvirt documentation</td>
<td>O</td>
<td>-</td>
</tr>
<tr>
<td>READONLY</td>
<td>Set how the image is exposed by the hypervisor</td>
<td>O e.g.: yes, no. This attribute should only be used for special storage configurations</td>
<td>-</td>
</tr>
<tr>
<td>IO</td>
<td>Set IO policy. Values are threads, native</td>
<td>O</td>
<td>-</td>
</tr>
<tr>
<td>TOTAL_BYTES_SEC, READ_BYTES_SEC, WRITE_BYTES_SEC, TOTAL_IOPS_SEC, READ_IOPS_SEC, WRITE_IOPS_SEC</td>
<td>IO throttling attributes for the disk. They are specified in bytes or IOPS (IO Operations) and can be specified for the total (read+write) or specific for read or write. Total and read or write can not be used at the same time. By default these parameters are only allowed to be used by oneadmin.</td>
<td>O</td>
<td>-</td>
</tr>
<tr>
<td>VCENTER_ADAPTER_TYPE</td>
<td>Possible values (careful with the case): lsiLogic, ide, busLogic. More information in the VMware documentation</td>
<td>-</td>
<td>O</td>
</tr>
<tr>
<td>VCENTER_DISK_TYPE</td>
<td>Possible values (careful with the case): thin, thick, .... More information in the VMware documentation</td>
<td>-</td>
<td>O</td>
</tr>
</tbody>
</table>

**Disks Device Mapping**

If the TARGET attribute is not set for a disk, OpenNebula will automatically assign it using the following precedence, starting with dev_prefix + a:

- First OS type Image.
- Contextualization CDROM.
- CDROM type Images.
- The rest of DATABLOCK and OS Images, and Volatile disks.
Please visit the guide for *managing images* and the *image template reference* to learn more about the different image types.

You can find a complete description of the contextualization features in the *contextualization guide*.

The default device prefix *sd* can be changed to *hd* or other prefix that suits your virtualization hypervisor requirements. You can find more information in the daemon configuration guide.

### An Example

This a sample section for disks. There are four disks using the image repository, and two volatile ones. Note that *fs* and *swap* are generated on-the-fly:

```bash
# First OS image, will be mapped to sda. Use image with ID 2
DISK = [ IMAGE_ID = 2 ]

# First DATABLOCK image, mapped to sdb.
# Use the Image named Data, owned by the user named oneadmin.
DISK = [ IMAGE = "Data",
   IMAGE_UNAME = "oneadmin" ]

# Second DATABLOCK image, mapped to sdc
# Use the Image named Results owned by user with ID 7.
DISK = [ IMAGE = "Results",
   IMAGE_UID = 7 ]

# Third DATABLOCK image, mapped to sdd
# Use the Image named Experiments owned by user instantiating the VM.
DISK = [ IMAGE = "Experiments" ]

# Volatile filesystem disk, sde
DISK = [ TYPE = fs,
   SIZE = 4096,
   FORMAT = ext3 ]

# swap, sdf
DISK = [ TYPE = swap,
   SIZE = 1024 ]
```

Because this VM did not declare a CONTEXT or any disk using a CDROM Image, the first DATABLOCK found is placed right after the OS Image, in *sdb*. For more information on image management and moving please check the Storage guide.
## 7.2.9 Network Section

<table>
<thead>
<tr>
<th>NIC Sub-Attribute</th>
<th>Description</th>
<th>KVM</th>
<th>vCenter</th>
<th>LXD</th>
</tr>
</thead>
<tbody>
<tr>
<td>NETWORK_ID</td>
<td>ID of the network to attach this device, as defined by onevnet. Use if no NETWORK</td>
<td>M (No NETWORK)</td>
<td>M (No NETWORK)</td>
<td>M (No NETWORK)</td>
</tr>
<tr>
<td>NETWORK</td>
<td>Name of the network to use (of those owned by user). Use if no NETWORK_ID</td>
<td>M (No NETWORK_ID)</td>
<td>M (No NETWORK_ID)</td>
<td>M (No NETWORK_ID)</td>
</tr>
<tr>
<td>NETWORK_UID</td>
<td>To select the NETWORK of a given user by her ID</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>NETWORK_UNAME</td>
<td>To select the NETWORK of a given user by her NAME</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>IP</td>
<td>Request an specific IP from the NETWORK</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>MAC</td>
<td>Request an specific HW address from the network interface</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>BRIDGE</td>
<td>Name of the bridge the network device is going to be attached to.</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>TARGET</td>
<td>name for the tun device created for the VM</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>SCRIPT</td>
<td>name of a shell script to be executed after creating the tun device for the VM</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>MODEL</td>
<td>hardware that will emulate this network interface. In KVM you can choose <code>virtio</code> to select its specific virtualization IO framework</td>
<td>O</td>
<td>O</td>
<td>-</td>
</tr>
<tr>
<td>FILTER</td>
<td>to define a network filtering rule for the interface</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>SECURITY_GROUPS</td>
<td>command separated list of the ids of the security groups to be applied to the interface.</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>IN-BOUND_AVG_BW</td>
<td>Average bitrate for the interface in kilobytes/second for inbound traffic</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>IN-BOUND_PEAK_BW</td>
<td>Maximum bitrate for the interface in kilobytes/second for inbound traffic</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>IN-BOUND_PEAK_KB</td>
<td>Data that can be transmitted at peak speed in kilobytes.</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>OUT-BOUND_AVG_BW</td>
<td>Average bitrate for the interface in kilobytes/second for outbound traffic</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>OUT-BOUND_PEAK_BW</td>
<td>Maximum bitrate for the interface in kilobytes/second for outbound traffic</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>OUT-BOUND_PEAK_KB</td>
<td>Data that can be transmitted at peak speed in kilobytes.</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>NETWORK_MODE</td>
<td>To let the Scheduler pick the VNET if set to <code>auto</code>, any other value will be ignored By default, the network mode is not set.</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>SCHED_REQUIREMENTS</td>
<td>If set to <code>auto</code>, dm movement when NETMORW_MODE is <code>auto</code>.</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>SCHED_RANK</td>
<td>Define the rank when NETMORW_MODE is <code>auto</code>.</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>NAME</td>
<td>Name of the nic.</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PARENT</td>
<td>It is used only on alias, it references the nic which is alias of.</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EXTERNAL</td>
<td>It is used only on alias, it indicates if the alias is external to the VM or not. If it is set to “yes” it will call pre, post, clean and reconfigure actions. If it set to “no” or it is empty, it will just call reconfigure action.</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Warning: The PORTS and ICMP attributes require the firewalling functionality to be configured. Please read the firewall configuration guide.

Example, a VM with two NIC attached to two different networks:

```plaintext
NIC = [ NETWORK_ID = 1 ]

NIC = [ NETWORK = "Blue", NETWORK_UID = 0 ]

NIC = [ NETWORK_MODE = "auto", SCHED_REQUIREMENTS = "TRAFFIC_TYPE="public"" ]
```

Example, a VM with two NIC attached, one is an alias of the other one:

```plaintext
NIC = [ NETWORK = "Test", NAME = "TestName" ]

NIC_ALIAS = [ NETWORK = "Test", PARENT = "TestName" ]
```

For more information on setting up virtual networks please check the Managing Virtual Networks guide.

Network Defaults

You can define a NIC_DEFAULT attribute with values that will be copied to each new NIC. This is specially useful for an administrator to define configuration parameters, such as MODEL, that final users may not be aware of.

```plaintext
NIC_DEFAULT = [ MODEL = "virtio" ]
```

7.2.10 I/O Devices Section

The following I/O interfaces can be defined for a VM:

Note the hypervisor column states that the attribute is Optional, Mandatory, or – not supported for that hypervisor

---

7.2. Virtual Machine Definition Template
### Attribute Description

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>KVM</th>
<th>vCenter</th>
<th>LXD</th>
</tr>
</thead>
</table>
| **INPUT** | Define input devices, available sub-attributes:  
- **TYPE:** values are mouse or tablet  
- **BUS:** values are usb, ps2 | O | - | - |
| **GRAPHICS** | Whether the VM should export its graphical display and how, available sub-attributes:  
- **TYPE:** values: vnc, sdl, spice  
- **LISTEN:** IP to listen on.  
- **PORT:** port for the VNC server  
- **PASSWD:** password for the VNC server  
- **KEYMAP:** keyboard configuration locale to use in the VNC display  
- **RANDOM_PASSWD:** if “YES”, generate a random password for each VM | O | O (vnc) | O |

**Example:**

7.2. Virtual Machine Definition Template
GRAPHICS = [
    TYPE = "vnc",
    LISTEN = "0.0.0.0",
    PORT = "5905"
]

**Warning:** For KVM hypervisor the port number is a real one, not the VNC port. So for VNC port 0 you should specify 5900, for port 1 is 5901 and so on.

**Warning:** OpenNebula will prevent VNC port collision within a cluster to ensure that a VM can be deployed or migrated to any host in the selected cluster. If the selected port is in use the VM deployment will fail. If the user does not specify the port variable, OpenNebula will try to assign VNC_PORTS[START] + VMID, or the first lower available port. The VNC_PORTS[START] is specified inside the oned.conf file.

### 7.2.11 Context Section

Context information is passed to the Virtual Machine via an ISO mounted as a partition. This information can be defined in the VM template in the optional section called Context, with the following attributes:

**Note** the hypervisor column states that the attribute is Optional, – not supported for that hypervisor or only valid for Linux guests.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VARIABLE</td>
<td>Variables that store values related to this virtual machine or others. The name of the variable is arbitrary (in the example, we use hostname).</td>
</tr>
<tr>
<td>FILES *</td>
<td>space-separated list of paths to include in context device.</td>
</tr>
<tr>
<td>FILES_DS</td>
<td>space-separated list of File images to include in context device. (Not supported for vCenter)</td>
</tr>
<tr>
<td>INIT_SCRIPTS</td>
<td>If the VM uses the OpenNebula contextualization package the init.sh file is executed by default. When the init script contains more than one init script is added, this list contains the scripts to run and the order. Ex. &quot;init.sh users.sh mysql.sh&quot;</td>
</tr>
<tr>
<td>START_SCRIPT</td>
<td>Text of the script executed when the machine starts up. It can contain shebang in case it is not shell script. For example START_SCRIPT=&quot;yum upgrade&quot;</td>
</tr>
<tr>
<td>START_SCRIPT_BASE64</td>
<td>The same as START_SCRIPT but encoded in Base64</td>
</tr>
<tr>
<td>TARGET</td>
<td>device to attach the context ISO.</td>
</tr>
<tr>
<td>DEV_PREFIX</td>
<td>device prefix for the context ISO, either sd, or hd</td>
</tr>
<tr>
<td>TOKEN</td>
<td>YES to create a token.txt file for OneGate monitorization</td>
</tr>
<tr>
<td>NETWORK</td>
<td>YES to fill automatically the networking parameters for each NIC, used by the Contextualization packages</td>
</tr>
<tr>
<td>SET_HOSTNAME</td>
<td>This parameter value will be the hostname of the VM.</td>
</tr>
<tr>
<td>DNS_HOSTNAME</td>
<td>YES to set the VM hostname to the reverse dns name (from the first IP)</td>
</tr>
<tr>
<td>EC2_HOSTNAME</td>
<td>YES to set the VM hostname based on main IP in format ip-A.B.C.D (defaults to NO)</td>
</tr>
<tr>
<td>GATEWAY_IFACE</td>
<td>This variable can be set to the interface number you want to configure the gateway. It is set by default. For example to set the first interface to configure the gateway you use GATEWAY_IFACE=0</td>
</tr>
<tr>
<td>ETHx_MAC</td>
<td>Used to find the correct interface</td>
</tr>
<tr>
<td>ETHx_IP</td>
<td>IPv4 address for the interface</td>
</tr>
<tr>
<td>ETHx_IPV6</td>
<td>IPv6 address for the interface</td>
</tr>
<tr>
<td>ETHx_NETWORK</td>
<td>Network address of the interface</td>
</tr>
<tr>
<td>ETHx_MASK</td>
<td>Network mask</td>
</tr>
<tr>
<td>ETHx_GATEWAY</td>
<td>Default IPv4 gateway for the interface</td>
</tr>
<tr>
<td>ETHx_GATEWAY6</td>
<td>Default IPv6 gateway for the interface</td>
</tr>
<tr>
<td>ETHx_MTU</td>
<td>MTU value for the interface</td>
</tr>
<tr>
<td>ETHx_DNS</td>
<td>DNS for the network</td>
</tr>
<tr>
<td>ETHx_ALIASy_MAC</td>
<td>Used to find the correct interface</td>
</tr>
</tbody>
</table>

7.2. Virtual Machine Definition Template 228
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETHx_ALIASy_IP</td>
<td>IPv4 address for the alias</td>
</tr>
<tr>
<td>ETHx_ALIASy_IP6</td>
<td>IPv6 address for the alias. Legacy ETHx_ALIASy_IPV6 is also valid</td>
</tr>
<tr>
<td>ETHx_ALIASy_IP6_PREFIX_LENGTH</td>
<td>IPv6 prefix length for the alias</td>
</tr>
<tr>
<td>ETHx_ALIASy_IPV6_ULA</td>
<td>IPv6 unique local address for the alias</td>
</tr>
<tr>
<td>ETHx_ALIASy_NETWORK</td>
<td>Network address of the alias</td>
</tr>
<tr>
<td>ETHx_ALIASy_MASK</td>
<td>Network mask</td>
</tr>
<tr>
<td>ETHx_ALIASy_GATEWAY</td>
<td>Default IPv4 gateway for the alias</td>
</tr>
<tr>
<td>ETHx_ALIASy_GATEWAY6</td>
<td>Default IPv6 gateway for the alias</td>
</tr>
<tr>
<td>ETHx_ALIASy_MTU</td>
<td>MTU value for the alias</td>
</tr>
<tr>
<td>ETHx_ALIASy_DNS</td>
<td>DNS for the alias</td>
</tr>
<tr>
<td>ETHx_ALIASy_EXTERNAL</td>
<td>Indicates if the alias is external to the VM or not</td>
</tr>
<tr>
<td>USERNAME</td>
<td>User to be created in the guest OS. If any password attribute is defined (see below) it will change this user (defaults to root).</td>
</tr>
<tr>
<td>CRYPTED_PASSWORD_BASE64</td>
<td>Crypted password encoded in base64. To be set for the user USERNAME.</td>
</tr>
<tr>
<td>PASSWORD_BASE64</td>
<td>Password encoded in base64. To be set for the user USERNAME.</td>
</tr>
<tr>
<td>CRYPTED_PASSWORD</td>
<td>Crypted password. To be set for the user USERNAME. This parameter is not recommended, use CRYPTED_PASSWORD_BASE64 instead.</td>
</tr>
<tr>
<td>PASSWORD</td>
<td>Password to be set for the user USERNAME. This parameter is not recommended, use CRYPTED_PASSWORD_BASE64 instead.</td>
</tr>
<tr>
<td>SSH_PUBLIC_KEY</td>
<td>Key to be added to USERNAME authorized_keys file or root in case USERNAME.</td>
</tr>
<tr>
<td>EC2_PUBLIC_KEY</td>
<td>Same as SSH_PUBLIC_KEY</td>
</tr>
<tr>
<td>SECURETTY</td>
<td>If set to NO it will disable securetty validation on PAM. If set to YES it will restore system defaults. Defaults: LXD -&gt; YES, KVM -&gt; NO.</td>
</tr>
<tr>
<td>TIMEZONE</td>
<td>Time zone to set. On Linux, the name must match the zone file name relative to /usr/share/zoneinfo/ (e.g. US/Central). On Windows, the name must match supported zone listed by tzutil /l (e.g. Central Standard Time).</td>
</tr>
<tr>
<td>GROW_ROOTFS</td>
<td>If set to NO, the automatic root filesystem growing will be disabled.</td>
</tr>
</tbody>
</table>

**Note:** Limitations apply in vCenter alias for attach/detach nic operations.

**Note:** If more than one of the password changing attributes listed above is defined, only the one with highest priority will be applied. The priority is the same as the order of appearance in this table.

The values referred to by VARIABLE can be defined:

**Hardcoded values:**

```plaintext
SET_HOSTNAME   = "MAINHOST"
```

**Using template variables**

```plaintext
$<template_variable>: any single value variable of the VM template, like for example:
```

```plaintext
IP_GEN        = "10.0.0.$VMID"
SET_HOSTNAME  = "$NAME"
```

```plaintext
$<template_variable>[<attribute>]: Any single value contained in a multiple value variable in the VM template, like for example:
```

```plaintext
IP_PRIVATE = $NIC[IP]
```

```plaintext
$<template_variable>[<attribute>, <attribute2>=<value2>]: Any single value contained in the variable of the VM template, setting one attribute to discern between multiple variables called the same way, like for example:
```

7.2. Virtual Machine Definition Template 229
Using Virtual Network template variables

\$NETWORK[<vnet_attribute>, <NETWORK_ID|NETWORK|NIC_ID>=<vnet_id|vnet_name|nic_id>]: Any single value variable in the Virtual Network template, like for example:

\[\text{dns} = \"\$\text{NETWORK}[\text{DNS}, \text{NETWORK_ID}=3]\\]

Note: The network MUST be in used by any of the NICs defined in the template. The vnet_attribute can be TEMPLATE to include the whole vnet template in XML (base64 encoded).

Using Image template variables

\$IMAGE[<image_attribute>, <IMAGE_ID|IMAGE>=<img_id|img_name>]: Any single value variable in the Image template, like for example:

\[\text{root} = \"\$\text{IMAGE}[\text{ROOT_PASS}, \text{IMAGE_ID}=0]\\]

Note: The image MUST be in used by any of the DISKs defined in the template. The image_attribute can be TEMPLATE to include the whole image template in XML (base64 encoded).

Using User template variables

\$USER[<user_attribute>]: Any single value variable in the user (owner of the VM) template, like for example:

\[\text{ssh_key} = \"\$\text{USER}[\text{SSH_KEY}]\\]

Note: The user_attribute can be TEMPLATE to include the whole user template in XML (base64 encoded).

Pre-defined variables, apart from those defined in the template you can use:

- \$UID, the uid of the VM owner
- \$UNAME, the name of the VM owner
- \$GID, the id of the VM owner’s group
- \$GNAME, the name of the VM owner’s group
- \$TEMPLATE, the whole template in XML format and encoded in base64

FILES_DS, each file must be registered in a FILE_DS datastore and has to be of type CONTEXT. Use the following to select files from Files Datastores:

- \$FILE[IMAGE=<image name>], to select own files
- \$FILE[IMAGE=<image name>, <IMAGE_UNAME|IMAGE_UID>=<owner name|owner id>], to select images owned by other users, by user name or uid.
- \$FILE[IMAGE_ID=<image id>], global file selection

Example:
7.2.12 Placement Section

The following attributes sets placement constraints and preferences for the VM, valid for all hypervisors:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCHED_REQUIREMENTS</td>
<td>An expression that rules out provisioning hosts from list of machines suitable to run this VM.</td>
</tr>
<tr>
<td>SCHED_RANK</td>
<td>This field sets which attribute will be used to sort the suitable hosts for this VM. Basically, it defines which hosts are more suitable than others.</td>
</tr>
<tr>
<td>SCHED_DS_REQUIREMENTS</td>
<td>An expression that rules out entries from the pool of datastores suitable to run this VM.</td>
</tr>
<tr>
<td>SCHED_DS_RANK</td>
<td>States which attribute will be used to sort the suitable datastores for this VM. Basically, it defines which datastores are more suitable than others.</td>
</tr>
<tr>
<td>USER_PRIORITY</td>
<td>Alter the standard FIFO ordering to dispatch VMs. VMs with a higher USER_PRIORITY will be dispatched first.</td>
</tr>
</tbody>
</table>

Example:

```
SCHED_REQUIREMENTS = "CPUSPEED > 1000"
SCHED_RANK = "FREE_CPU"
SCHED_DS_REQUIREMENTS = "NAME=GoldenCephDS"
SCHED_DS_RANK = "FREE_MB"
```

**Requirement Expression Syntax**

The syntax of the requirement expressions is defined as:

```
stmt::= expr';'
expr::= VARIABLE '=' NUMBER
   | VARIABLE '!=' NUMBER
   | VARIABLE '>' NUMBER
   | VARIABLE '<' NUMBER
   | VARIABLE '@>' NUMBER
   | VARIABLE '=' STRING
   | VARIABLE '!=' STRING
   | expr '&&' expr
   | expr '@>' expr
   | '!' expr
   | '(!' expr ')'
```

Each expression is evaluated to 1 (TRUE) or 0 (FALSE). Only those hosts for which the requirement expression is evaluated to TRUE will be considered to run the VM.
Logical operators work as expected (less '<', greater '>', '&&' AND, '||' OR, '!' NOT), '=' means equals with numbers (floats and integers). When you use '=' operator with strings, it performs a shell wildcard pattern matching. Additionally the '@>' operator means contains, if the variable evaluates to an array the expression will be true if that array contains the given number or string (or any string that matches the provided pattern).

Any variable included in the Host template or its Cluster template can be used in the requirements. You may also use an XPath expression to refer to the attribute.

There is a special variable, CURRENT_VMS, that can be used to deploy VMs in a Host where other VMs are (not) running. It can be used only with the operators '=' and '!='.

Examples:

```bash
# Only aquila hosts (aquila0, aquila1...), note the quotes
SCHED_REQUIREMENTS = "NAME = \"aquila\"

# Only those resources with more than 60% of free CPU
SCHED_REQUIREMENTS = "FREE_CPU > 60"

# Deploy only in the Host where VM 5 is running. Two different forms:
SCHED_REQUIREMENTS = "CURRENT_VMS = 5"
SCHED_REQUIREMENTS = "\"HOST/VMS/ID\" @> 5"

# Deploy in any Host, except the ones where VM 5 or VM 7 are running
SCHED_REQUIREMENTS = "(CURRENT_VMS != 5) & (CURRENT_VMS != 7)"

# Use any datastore that is in cluster 101 (it list of cluster IDs contains 101)
SCHED_DS_REQUIREMENTS = "\"CLUSTERS/ID\" @> 101"
```

**Warning:** If using OpenNebula’s default match-making scheduler in a hypervisor heterogeneous environment, it is a good idea to add an extra line like the following to the VM template to ensure its placement in a specific hypervisor.

```
SCHED_REQUIREMENTS = "HYPERVISOR=\"vcenter\"
```

**Warning:** Template variables can be used in the SCHED_REQUIREMENTS section.

- `$<template_variable>`: any single value variable of the VM template.
- `$<template_variable>[<attribute>]`: Any single value contained in a multiple value variable in the VM template.
- `$<template_variable>[<attribute>, <attribute2>=<value2>]`: Any single value contained in a multiple value variable in the VM template, setting one attribute to discern between multiple variables called the same way.

For example, if you have a custom probe that generates a MACS attribute for the hosts, you can do short of a MAC pinning, so only VMs with a given MAC runs in a given host.

```
SCHED_REQUIREMENTS = "MAC=\"$NIC[MAC]\"
```

**Rank Expression Syntax**

The syntax of the rank expressions is defined as:
Rank expressions are evaluated using each host information. ‘+’, ‘-’, ‘*’, ‘/’ and ‘-’ are arithmetic operators. The rank expression is calculated using floating point arithmetics, and then round to an integer value.

**Warning:** The rank expression is evaluated for each host, those hosts with a higher rank are used first to start the VM. The rank policy must be implemented by the scheduler. Check the configuration guide to configure the scheduler.

**Warning:** Similar to the requirements attribute, any number (integer or float) attribute defined for the host can be used in the rank attribute

Examples:

```
# First those resources with a higher Free CPU
SCHED_RANK = "FREE_CPU"

# Consider also the CPU temperature
SCHED_RANK = "FREE_CPU * 100 - TEMPERATURE"
```

### 7.2.13 vCenter Section

You have more information about vCenter attributes in the **vCenter Specifics Section**:

### 7.2.14 Public Cloud Section

To define a Virtual Machine in the supported cloud providers, the following attributes can be used in the PUBLIC_CLOUD section:

**Amazon EC2 Attributes**

More information in the Amazon EC2 Driver Section:
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE</td>
<td>Needs to be set to “EC2”</td>
<td>YES</td>
</tr>
<tr>
<td>AMI</td>
<td>Unique ID of a machine image, returned by a call to ec2-describe-images.</td>
<td>YES</td>
</tr>
<tr>
<td>AKI</td>
<td>The ID of the kernel with which to launch the instance.</td>
<td>NO</td>
</tr>
<tr>
<td>CLIENT-TOKEN</td>
<td>Unique, case-sensitive identifier you provide to ensure idem-potency of the request.</td>
<td>NO</td>
</tr>
<tr>
<td>INSTANCE-TYPE</td>
<td>Specifies the instance type.</td>
<td>YES</td>
</tr>
<tr>
<td>KEYPAIR</td>
<td>The name of the key pair, later will be used to execute commands like ssh -i id_keypair or scp -i id_keypair</td>
<td>NO</td>
</tr>
<tr>
<td>LICENSE-POOL</td>
<td>--license-pool</td>
<td>NO</td>
</tr>
<tr>
<td>BLOCK-DEVICEMAP-PING</td>
<td>The block device mapping for the instance. More than one can be specified in a space-separated list. Check the –block-device-mapping option of the EC2 CLI Reference for the syntax</td>
<td>NO</td>
</tr>
<tr>
<td>PLACEMENT-GROUP</td>
<td>Name of the placement group.</td>
<td>NO</td>
</tr>
<tr>
<td>PRIVATEIP</td>
<td>If you’re using Amazon Virtual Private Cloud, you can optionally use this parameter to assign the instance a specific available IP address from the subnet.</td>
<td>NO</td>
</tr>
<tr>
<td>RAMDISK</td>
<td>The ID of the RAM disk to select.</td>
<td>NO</td>
</tr>
<tr>
<td>SUBNETID</td>
<td>If you’re using Amazon Virtual Private Cloud, this specifies the ID of the subnet you want to launch the instance into. This parameter is also passed to the command ec2-associate-address -i i-0041230 -a elasticip.</td>
<td>NO</td>
</tr>
<tr>
<td>TENANCY</td>
<td>The tenancy of the instance you want to launch.</td>
<td>NO</td>
</tr>
<tr>
<td>USER-DATA</td>
<td>Specifies Base64-encoded MIME user data to be made available to the instance(s) in this reservation.</td>
<td>NO</td>
</tr>
<tr>
<td>SECURITY-GROUPS</td>
<td>Name of the security group. You can specify more than one security group (comma separated).</td>
<td>NO</td>
</tr>
<tr>
<td>SECURITY-GROUPIDS</td>
<td>Ids of the security group. You can specify more than one security group (comma separated).</td>
<td>NO</td>
</tr>
<tr>
<td>ELASTICIP</td>
<td>EC2 Elastic IP address to assign to the instance. This parameter is passed to the command ec2-associate-address -i i-0041230 elasticip.</td>
<td>NO</td>
</tr>
<tr>
<td>TAGS</td>
<td>Key and optional value of the tag, separated by an equals sign (=). You can specify more than one tag (comma separated).</td>
<td>NO</td>
</tr>
<tr>
<td>AVAILABILITY-ZONE</td>
<td>The Availability Zone in which to run the instance.</td>
<td>NO</td>
</tr>
<tr>
<td>HOST</td>
<td>Defines which OpenNebula host will use this template</td>
<td>NO</td>
</tr>
<tr>
<td>EBS_OPTIMIZED</td>
<td>Obtain a better I/O throughput for VMs with EBS provisioned volumes</td>
<td>NO</td>
</tr>
</tbody>
</table>

**Azure Attributes**

More information in the Azure Driver Section:
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE</td>
<td>Needs to be set to “AZURE”</td>
<td>YES</td>
</tr>
<tr>
<td>INSTANCE_TYPE</td>
<td>Specifies the capacity of the VM in terms of CPU and memory</td>
<td>YES</td>
</tr>
<tr>
<td>IMAGE</td>
<td>Specifies the base OS of the VM. There are various ways to obtain the list of valid images for Azure, the simplest one is detailed here</td>
<td>YES</td>
</tr>
<tr>
<td>VM_USER</td>
<td>If the selected IMAGE is prepared for Azure provisioning, a username can be specified here to access the VM once booted</td>
<td>NO</td>
</tr>
<tr>
<td>VM_PASSWORD</td>
<td>Password for VM_USER</td>
<td>NO</td>
</tr>
<tr>
<td>LOCATION</td>
<td>Azure datacenter where the VM will be sent. See /etc/one/az_driver.conf for possible values (use the name of the section, not the region names). Spaces are not supported in this value.</td>
<td>NO</td>
</tr>
<tr>
<td>STORAGE_ACCOUNT</td>
<td>Specify the storage account where this VM will belong</td>
<td>NO</td>
</tr>
<tr>
<td>WIN_RM</td>
<td>Comma-separated list of possible protocols to access this Windows VM</td>
<td>NO</td>
</tr>
<tr>
<td>CLOUD_SERVICE</td>
<td>Specifies the name of the cloud service where this VM will be linked. Defaults to “csn&lt;vid&gt;”, where vid is the id of the VM”.</td>
<td>NO</td>
</tr>
<tr>
<td>TCP_ENDPOINTS</td>
<td>Comma-separated list of TCP ports to be accesible from the public internet to this VM</td>
<td>NO</td>
</tr>
<tr>
<td>SSHPORT</td>
<td>Port where the VMs ssh server will listen on</td>
<td>NO</td>
</tr>
<tr>
<td>VIRTUAL_NETWORK_NAME</td>
<td>Name of the virtual network to which this VM will be connected</td>
<td>NO</td>
</tr>
<tr>
<td>SUBNET</td>
<td>Name of the particular Subnet where this VM will be connected to</td>
<td>NO</td>
</tr>
<tr>
<td>AVAILABILITY_SET</td>
<td>Name of the availability set to which this VM will belong</td>
<td>NO</td>
</tr>
<tr>
<td>AFFINITY_GROUP</td>
<td>Affinity groups allow you to group your Azure services to optimize performance. All services and VMs within an affinity group will be located in the same region belong</td>
<td>NO</td>
</tr>
</tbody>
</table>

**Predefined Host Attributes**

There are some predefined Host attributes that can be used in the requirements and rank expressions, valid for all hypervisors:
### Attribute | Meaning
--- | ---
**NAME** | Hostname.
**MAX_CPU** | Total CPU in the host, in (# cores * 100).
**CPU_USAGE** | Allocated used CPU in (# cores * 100). This value is the sum of all the CPU requested by VMs running on the host, and is updated instantly each time a VM is deployed or undeployed.
**FREE_CPU** | Real free CPU in (# cores * 100), as returned by the probes. This value is updated each monitorization cycle.
**USED_CPU** | Real used CPU in (# cores * 100), as returned by the probes. USED_CPU = MAX_CPU - FREE_CPU. This value is updated each monitorization cycle.
**MAX_MEM** | Total memory in the host, in KB.
**MEM_USAGE** | Allocated used memory in KB. This value is the sum of all the memory requested by VMs running on the host, and is updated instantly each time a VM is deployed or undeployed.
**FREE_MEM** | Real free memory in KB, as returned by the probes. This value is updated each monitorization cycle.
**USED_MEM** | Real used memory in KB, as returned by the probes. USED_MEM = MAX_MEM - FREE_MEM. This value is updated each monitorization cycle.
**RUNNING_VMS** | Number of VMs deployed on this host.
**HYPERVISOR** | Hypervisor name.

You can execute `onehost show <id> -x` to see all the attributes and their values.

**Note:** Check the Monitoring Subsystem guide to find out how to extend the information model and add any information probe to the Hosts.

### 7.2.15 Hypervisor Section

You can also tune several low-level hypervisor attributes.

The **RAW** attribute (optional) section of the VM template is used pass VM information directly to the underlying hypervisor. Anything placed in the data attribute gets passed straight to the hypervisor unmodified.

<table>
<thead>
<tr>
<th>RAW Attribute</th>
<th>Description</th>
<th>KVM</th>
<th>vCenter</th>
<th>LXD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TYPE</strong></td>
<td>Possible values are: kvm, lxd, vmware</td>
<td>O</td>
<td>-</td>
<td>O</td>
</tr>
<tr>
<td><strong>DATA</strong></td>
<td>Raw data to be passed directly to the hypervisor</td>
<td>O</td>
<td>-</td>
<td>O</td>
</tr>
<tr>
<td><strong>DATA_VMX</strong></td>
<td>Raw data to be added directly to the .vmx file</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Example:

```
RAW = {
    type = "kvm",
    data = "<devices><serial type="pty">
            <source path="/dev/pts/5" />
            <target port="0"/>
        </serial>
        <console type="pty" ttymode="0x2" path="/dev/pts/5"/>
        <target port="0"/>
    </devices>"
}
```

Additionally the following can be also set for KVM

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EMULATOR</strong></td>
<td>Path to the emulator binary to use with this VM</td>
</tr>
</tbody>
</table>

### 7.2. Virtual Machine Definition Template
Example:

\texttt{EMULATOR="/usr/bin/qemu-system-aarch64"}

### 7.2.16 Restricted Attributes

All the \texttt{default} restricted attributes to users in the oneadmin group are summarized in the following list:

- CONTEXT/FILES
- NIC/MAC
- NIC/VLAN_ID
- NIC/BRIDGE
- NIC/INBOUND_AVG_BW
- NIC/INBOUND_PEAK_BW
- NIC/INBOUND_PEAK_KB
- NIC/OUTBOUND_AVG_BW
- NIC/OUTBOUND_PEAK_BW
- NIC/OUTBOUND_PEAK_KB
- NIC_DEFAULT/MAC
- NIC_DEFAULT/VLAN_ID
- NIC_DEFAULT/BRIDGE
- NIC/OpenNebula_Managed
- DISK/TOTAL_BYTES_SEC
- DISK/READ_BYTES_SEC
- DISK/WRITE_BYTES_SEC
- DISK/TOTAL_IOPS_SEC
- DISK/READ_IOPS_SEC
- DISK/WRITE_IOPS_SEC
- DISK/OpenNebula_Managed
- CPU_COST
- MEMORY_COST
- DISK_COST
- DEPLOY_FOLDER

These attributes can be configured in oned.conf.

### 7.2.17 User Inputs

\texttt{USER_INPUTS} provides the template creator with the possibility to dynamically ask the user instantiating the template for dynamic values that must be defined.
Note that the CONTEXT references the variables defined in the USER_INPUTS so the value is injected into the VM.

Valid types:

<table>
<thead>
<tr>
<th>Types</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>text</td>
<td>&lt;VAR&gt;=&quot;M</td>
<td>text</td>
</tr>
<tr>
<td>text64</td>
<td>&lt;VAR&gt;=&quot;M</td>
<td>text64</td>
</tr>
<tr>
<td>password</td>
<td>&lt;VAR&gt;=&quot;M</td>
<td>password</td>
</tr>
<tr>
<td>number</td>
<td>&lt;VAR&gt;=&quot;M</td>
<td>number</td>
</tr>
<tr>
<td>float</td>
<td>&lt;VAR&gt;=&quot;M</td>
<td>number-float</td>
</tr>
<tr>
<td>range</td>
<td>&lt;VAR&gt;=&quot;M</td>
<td>range</td>
</tr>
<tr>
<td>range (float)</td>
<td>&lt;VAR&gt;=&quot;M</td>
<td>range-float</td>
</tr>
<tr>
<td>list</td>
<td>&lt;VAR&gt;=&quot;M</td>
<td>list</td>
</tr>
<tr>
<td>boolean</td>
<td>&lt;VAR&gt;=&quot;M</td>
<td>boolean</td>
</tr>
</tbody>
</table>

There is the possibility of making the USER_INPUT mandatory or not. If it is mandatory, we will see a letter ‘M’ but if it is not mandatory a letter ‘O’ will appear. Example:

- <VAR>="M... This is mandatory
- <VAR>="O... This is not mandatory

In Sunstone, the USER_INPUTS can be ordered with the mouse.
### 7.2.18 Schedule actions Section

The following attributes can use to define punctual or relative actions for the VM.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIME</td>
<td>Time in seconds to start the action.</td>
</tr>
<tr>
<td>REPEAT</td>
<td>Define the granularity of the action [ WEEKLY = 0, MONTHLY = 1, YEARLY = 2, HOURLY = 3 ].</td>
</tr>
<tr>
<td>DAYS</td>
<td>Sets the frequency for recurring actions. The specific values depends on the REPEAT mode, i.e. for yearly periods DAYS=“1,365” would mean the first and last day of the a year</td>
</tr>
<tr>
<td>ACTION</td>
<td>The action that will be executed.</td>
</tr>
<tr>
<td>END_TYPE</td>
<td>When the users want end the action [ NEVER = 0, NUMBER OF REPETITIONS = 1, DATE = 2 ].</td>
</tr>
<tr>
<td>END_VALUE</td>
<td>The value for END_TYPE attribute, can be a number or a date.</td>
</tr>
</tbody>
</table>

Example:

```json
SCHED_ACTION=[
  ACTION="suspend",
  DAYS="1,5",
  END_TYPE="1",
  END_VALUE="5",
  ID="0",
  REPEAT="0",
  TIME="1537653600"
]
```
7.2.19 NUMA topology Section

The following attributes can use to define a NUMA topology for the VM.

<table>
<thead>
<tr>
<th>TOPOLOGY attribute</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIN_POLICY</td>
<td>vCPU pinning preference: CORE, THREAD, SHARED, NONE</td>
</tr>
<tr>
<td>SOCKETS</td>
<td>Number of sockets or NUMA nodes.</td>
</tr>
<tr>
<td>CORES</td>
<td>Number of cores per node</td>
</tr>
<tr>
<td>THREADS</td>
<td>Number of threads per core</td>
</tr>
<tr>
<td>HUGEPAGE_SIZE</td>
<td>Size of the hugepages (MB). If not defined no hugepages will be used</td>
</tr>
<tr>
<td>MEMORY_ACCESS</td>
<td>Control if the memory is to be mapped shared or private</td>
</tr>
</tbody>
</table>

Example:

```plaintext
TOPOLOGY = [
    HUGEPAGE_SIZE = "2",
    MEMORY_ACCESS = "shared",
    NUMA_NODES = "2",
    PIN_POLICY = "THREAD"
]
```

Asymmetric NUMA configurations, i.e. not distributing the VM resources evenly across the nodes, can be defined manually setting the NUMA_NODE attribute:

<table>
<thead>
<tr>
<th>NUMA_NODE attribute</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEMORY</td>
<td>Memory allocated in the node, in MB</td>
</tr>
<tr>
<td>TOTAL_CPUS</td>
<td>Total number of CPU units, CORE*THREADS</td>
</tr>
</tbody>
</table>

For example:

```plaintext
TOPOLOGY = [ PIN_POLICY = CORE, SOCKETS = 2 ]
NUMA_NODE = [ MEMORY = 1024, TOTAL_CPUS = 2 ]
NUMA_NODE = [ MEMORY = 2048, TOTAL_CPUS = 4 ]
```

Please check the NUMA guide for more information.

7.3 Virtual Machines States Reference

This page is a complete reference of all the VM states that will be useful for administrators doing troubleshooting and developers.

The simplified life-cycle is explained in the Managing Virtual Machines guide. That simplified diagram uses a smaller number of state names. These names are the ones used by onevm list, e.g. prolog, prolog_migrate and prolog_resume are all presented as prol. It is intended as a reference for end-users. That section should be enough for end-users and every-day administration tasks.

7.3.1 List of States

In OpenNebula a Virtual Machine has 2 variables to define its state: STATE and LCM_STATE. The LCM_STATE is only relevant when the STATE is ACTIVE. Both states can be seen from the CLI (onevm show) and from Sunstone
(Info panel for the VM).

<table>
<thead>
<tr>
<th>#</th>
<th>State</th>
<th>LCM State</th>
<th>Short State Alias</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>INIT</td>
<td>init</td>
<td>Internal initialization state</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>PENDING</td>
<td>pend</td>
<td>By default a VM starts in this state</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>HOLD</td>
<td>hold</td>
<td>The owner has held the VM and it will not be scheduled until it is released</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>ACTIVE</td>
<td>0</td>
<td>INIT</td>
<td>Internal initialization state</td>
</tr>
<tr>
<td>4</td>
<td>PROLOG</td>
<td>pro</td>
<td>The system is transferring the VM files (disk images and the recovery file) to the host in which the virtual machine will be running.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>BOOT</td>
<td>boot</td>
<td>OpenNebula is waiting for the hypervisor to create the VM (from UNDEPLOY)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>RUNNING</td>
<td>runn</td>
<td>The VM is running (not migrating)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>MIGRATE</td>
<td>migr</td>
<td>The VM is migrating from one host to another. This is a hot migration</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>SAVE_STOP</td>
<td>save</td>
<td>The system is saving the VM files after a stop operation</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>SAVE_SUSPEND</td>
<td>save</td>
<td>The system is saving the VM files for a cold migration</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>PROLOG_MIGRATE</td>
<td>migr</td>
<td>File transfers during a cold migration (from SUSPENDED)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>PROLOG_MIGRATE</td>
<td>migr</td>
<td>File transfers during a cold migration (from SUSPEND)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>PROLOG_RESUME</td>
<td>prol</td>
<td>File transfers after a resume action (from stopped)</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>EPILOG_STOP</td>
<td>epil</td>
<td>File transfers after a resume action (from undeployed)</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>EPILOG</td>
<td>epil</td>
<td>The system cleans up the Host used to virtualize the VM and additionally disk images to be saved are copied back to their datastores</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>SHUTDOWN</td>
<td>shut</td>
<td>OpenNebula has sent the shutdown ACPI signal and is waiting for it to complete the shutdown process. If after a certain timeout the VM state does not disappear, OpenNebula will assume that the guest OS ignored the ACPI signal and the VM state will be changed to an unknown state</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>CLEANUP_RESUBMIT</td>
<td>clea</td>
<td>Cleanup after a delete-recreate action</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>UNKNOWN</td>
<td>unk</td>
<td>The VM couldn’t be monitored, it is in an unknown state</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>HOTPLUG</td>
<td>hotp</td>
<td>A disk attach/detach operation is in progress</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>SHUTDOWN_POWEROFF</td>
<td>shut</td>
<td>OpenNebula has sent the shutdown ACPI signal and is waiting for it to complete the shutdown process. If after a certain timeout the VM state does not disappear, OpenNebula will assume that the guest OS ignored the ACPI signal and the VM state will be changed to an unknown state</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>BOOTUNKNOWN</td>
<td>boot</td>
<td>OpenNebula has sent the shutdown ACPI signal and is waiting for it to complete the shutdown process. If after a certain timeout the VM state does not disappear, OpenNebula will assume that the guest OS ignored the ACPI signal and the VM state will be changed to an unknown state</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>BOOT_MIGRATE</td>
<td>boot</td>
<td>OpenNebula has sent the shutdown ACPI signal and is waiting for it to complete the shutdown process. If after a certain timeout the VM state does not disappear, OpenNebula will assume that the guest OS ignored the ACPI signal and the VM state will be changed to an unknown state</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>BOOT_MIGRATE</td>
<td>boot</td>
<td>OpenNebula has sent the shutdown ACPI signal and is waiting for it to complete the shutdown process. If after a certain timeout the VM state does not disappear, OpenNebula will assume that the guest OS ignored the ACPI signal and the VM state will be changed to an unknown state</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>CLEANUP_DELETE</td>
<td>clea</td>
<td>Cleanup after a delete operation</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>HOTPLUG_SNAPSHOT</td>
<td>snap</td>
<td>A system snapshot action is in progress</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>HOTPLUG_NIC</td>
<td>hotp</td>
<td>A NIC attach/detach operation is in progress</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>HOTPLUG_SAVEAS</td>
<td>hotp</td>
<td>A disk-saveas operation is in progress</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>HOTPLUG_SAVEAS_POWEROFF</td>
<td>hotp</td>
<td>A disk-saveas operation is in progress</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>HOTPLUG_SAVEAS_SUSPENDED</td>
<td>hotp</td>
<td>A disk-saveas operation is in progress</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>SHUTDOWN_UNDEPLOY</td>
<td>shut</td>
<td>OpenNebula has sent the shutdown ACPI signal and is waiting for it to complete the shutdown process. If after a certain timeout the VM state does not disappear, OpenNebula will assume that the guest OS ignored the ACPI signal and the VM state will be changed to an unknown state</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>EPILOG_UNDEPLOY</td>
<td>epil</td>
<td>The system cleans up the Host used to virtualize the VM and additionally disk images to be saved are copied back to their datastores</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>PROLOG_UNDEPLOY</td>
<td>prol</td>
<td>File transfers after a resume action (from stopped)</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>BOOT_UNDEPLOY</td>
<td>boot</td>
<td>OpenNebula is waiting for the hypervisor to create the VM (from STOPPED)</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>HOTPLUG_PROLOG_POWEROFF</td>
<td>hotp</td>
<td>File transfers for a disk attach/detach operation are in progress</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>HOTPLUG_EPILOG_POWEROFF</td>
<td>hotp</td>
<td>File transfers for a disk attach/detach operation are in progress</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>BOOT_MIGRATE</td>
<td>boot</td>
<td>OpenNebula is waiting for the hypervisor to create the VM (from UNDEPLOY)</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>BOOT_FAILURE</td>
<td>fail</td>
<td>Failure during a boot operation</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>BOOT_MIGRATE_FAILURE</td>
<td>fail</td>
<td>Failure during a boot operation</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>PROLOG_MIGRATE_FAILURE</td>
<td>fail</td>
<td>Failure during a PROLOG_MIGRATE operation</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>PROLOG_FAILURE</td>
<td>fail</td>
<td>Failure during a PROLOG operation</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>EPILOG_FAILURE</td>
<td>fail</td>
<td>Failure during an EPILOG operation</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>EPILOG_STOP_FAILURE</td>
<td>fail</td>
<td>Failure during an EPILOG operation</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>EPILOG_UNDEPLOY_FAILURE</td>
<td>fail</td>
<td>Failure during an EPILOG operation</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>PROLOG_MIGRATE_POWEROFF</td>
<td>fail</td>
<td>File transfers during a cold migration (from SUSPEND)</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>PROLOG_MIGRATE_POWEROFF_FAILURE</td>
<td>fail</td>
<td>File transfers during a cold migration (from SUSPEND)</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>PROLOG_MIGRATE_SUSPEND</td>
<td>fail</td>
<td>File transfers during a cold migration (from SUSPEND)</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>PROLOG_MIGRATE_SUSPEND_FAILURE</td>
<td>fail</td>
<td>File transfers during a cold migration (from SUSPEND)</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>State</td>
<td>LCM State</td>
<td>Short State Alias</td>
<td>Meaning</td>
</tr>
<tr>
<td>---</td>
<td>--------------</td>
<td>-------------------</td>
<td>------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>47</td>
<td>BOOT_UNDEPLOY_FAILURE</td>
<td>fail</td>
<td>fail</td>
<td>Failure during a BOOT_UNDEPLOY</td>
</tr>
<tr>
<td>48</td>
<td>BOOT_STOPPED_FAILURE</td>
<td>fail</td>
<td>fail</td>
<td>Failure during a BOOT_STOPPED</td>
</tr>
<tr>
<td>49</td>
<td>PROLOG_RESUME_FAILURE</td>
<td>fail</td>
<td>fail</td>
<td>Failure during a PROLOG_RESUME</td>
</tr>
<tr>
<td>50</td>
<td>PROLOG_UNDEPLOY_FAILURE</td>
<td>fail</td>
<td>fail</td>
<td>Failure during a PROLOG_UNDEPLOY</td>
</tr>
<tr>
<td>51</td>
<td>DISK_SNAPSHOTPOWEROFF</td>
<td>snap</td>
<td>snap</td>
<td>A disk-snapshot-create</td>
</tr>
<tr>
<td>52</td>
<td>DISK_SNAPSHOT_REVERTPOWEROFF</td>
<td>snap</td>
<td>A disk-snapshot-revert</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>DISK_SNAPSHOT_DELETEPOWEROFF</td>
<td>snap</td>
<td>A disk-snapshot-delete</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>DISK_SNAPSHOT_SUSPENDED</td>
<td>snap</td>
<td>snap</td>
<td>A disk-snapshot-create</td>
</tr>
<tr>
<td>55</td>
<td>DISK_SNAPSHOT_REVERT_SUSPENDED</td>
<td>snap</td>
<td>A disk-snapshot-revert</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>DISK_SNAPSHOT_DELETE_SUSPENDED</td>
<td>snap</td>
<td>A disk-snapshot-delete</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>DISK_SNAPSHOT</td>
<td>snap</td>
<td>snap</td>
<td>A disk-snapshot-create</td>
</tr>
<tr>
<td>58</td>
<td>DISK_SNAPSHOT_DELETE</td>
<td>snap</td>
<td>snap</td>
<td>A disk-snapshot-delete</td>
</tr>
<tr>
<td>59</td>
<td>PROLOG_MIGRATE_UNKNOWN</td>
<td>fail</td>
<td>fail</td>
<td>Failure during a PROLOG_MIGRATE_UNKNOWN</td>
</tr>
<tr>
<td>60</td>
<td>PROLOG_MIGRATE_UNKNOWN_FAILURE</td>
<td>fail</td>
<td>Failure during a PROLOG_MIGRATE_UNKNOWN_FAILURE</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>DISK_RESIZE</td>
<td>dsrz</td>
<td>dsrz</td>
<td>Disk resize with the vm</td>
</tr>
<tr>
<td>62</td>
<td>DISK_RESIZE_POWEROFF</td>
<td>dsrz</td>
<td>dsrz</td>
<td>Disk resize with the vm</td>
</tr>
<tr>
<td>63</td>
<td>DISK_RESIZE_UNDEPLOYED</td>
<td>dsrz</td>
<td>dsrz</td>
<td>Disk resize with the vm</td>
</tr>
<tr>
<td>64</td>
<td>STOPPED</td>
<td>stop</td>
<td>The VM is stopped. VMs in this state will never run.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>SUSPENDED</td>
<td>susp</td>
<td>Same as stopped, but the files are left in the host for later resume.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>DONE</td>
<td>done</td>
<td>The VM is done. VMS in this state will never run.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>POWEROFF</td>
<td>poff</td>
<td>Same as suspended, but files are left in the host for later resume.</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>UNDEPLOYED</td>
<td>unde</td>
<td>The VM is shut down. VMS in this state will never run.</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>CLONING</td>
<td>clon</td>
<td>The VM is waiting for one or more disk images to finish the initial copy to the repository.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>CLONING_FAILURE</td>
<td>fail</td>
<td>Failure during a CLONING.</td>
<td></td>
</tr>
</tbody>
</table>

### 7.3.2 Diagram

You can click on the following image to open it in a new window. For a simplified version of this diagram, please visit the [Managing Virtual Machines guide](#).
7.4 Image Definition Template

This page describes how to define a new image template. An image template follows the same syntax as the VM template.

If you want to learn more about the image repository, you can do so here.

**Warning:** There are some template attributes that can compromise the security of the system or the security of other VMs, and can be used only by users in the oneadmin group. These attributes can be configured in oned.conf, the default ones are labeled with * in the following tables. See the complete list in the Restricted Attributes section.

7.4.1 Template Attributes

The following attributes can be defined in the template.
<table>
<thead>
<tr>
<th>Attribute</th>
<th>KVM</th>
<th>vCenter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME</td>
<td>Mandatory</td>
<td>Mandatory</td>
<td>Any string</td>
<td>Name that the Image will get. Every image must have a unique name.</td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>Optional</td>
<td>Optional</td>
<td>Any string</td>
<td>Human readable description of the image for other users.</td>
</tr>
<tr>
<td>TYPE</td>
<td>Optional</td>
<td>Optional</td>
<td>OS, CDROM, DATABLOCK for both KVM and vCenter, KERNEL, RAMDISK, CONTEXT</td>
<td>Type of the image, explained in detail in the following section. If omitted, the default value is the one defined in oned.conf (install default is OS).</td>
</tr>
<tr>
<td>PERSISTENT</td>
<td>Optional</td>
<td>Optional</td>
<td>YES, NO</td>
<td>Persistence of the image. If omitted, the default value is NO.</td>
</tr>
<tr>
<td>PERSISTENT_TYPE</td>
<td>Optional</td>
<td>-</td>
<td>IMMUTABLE</td>
<td>An special persistent image, that will not be modified. This attribute should only be used for special storage configurations.</td>
</tr>
<tr>
<td>DEV_PREFIX</td>
<td>Optional</td>
<td>Optional</td>
<td>Any string e.g sd, hd</td>
<td>Prefix for the emulated device this image will be mounted at. For instance, hd, sd, or vd for KVM virtio. If omitted, the default value is the one defined in oned.conf (installation default is hd).</td>
</tr>
<tr>
<td>TARGET</td>
<td>Optional</td>
<td>-</td>
<td>Any string</td>
<td>Target for the emulated device this image will be mounted at. For instance, hdb, sdc. If omitted, it will be assigned automatically.</td>
</tr>
<tr>
<td>DRIVER</td>
<td>Optional</td>
<td>-</td>
<td>KVM: raw, qcow2</td>
<td>Specific image mapping driver.</td>
</tr>
<tr>
<td>PATH</td>
<td>Mandatory (if no SOURCE)</td>
<td>Mandatory (if no SOURCE)</td>
<td>Any string</td>
<td>Path to the original file that will be copied to the image repository. If not specified for a DATABLOCK type image, an empty image will be created. Note that gzipped files are supported and OpenNebula will automatically decompress them. Bzip2 compressed files is also supported, but it’s strongly discouraged since OpenNebula will not calculate it’s size properly.</td>
</tr>
<tr>
<td>SOURCE</td>
<td>Mandatory (if no PATH)</td>
<td>Mandatory (if no PATH)</td>
<td>Any string</td>
<td>Source to be used in the DISK attribute. Useful for not file-based images.</td>
</tr>
<tr>
<td>DISK_TYPE</td>
<td>Optional</td>
<td>-</td>
<td>For KVM: BLOCK, CDROM or FILE (default). For vCenter: FILE</td>
<td>This is the type of the supporting media for the image: a block device (BLOCK) an ISO-9660 file or readonly block device (CDROM) or a plain file (FILE).</td>
</tr>
<tr>
<td>VCENTER_DISK_TYPE</td>
<td>Optional</td>
<td>-</td>
<td>vCenter: (careful with the case): delta,eagerZeroedThick,flatmonolithic,thin,eagerThin,preallocated,thick,thick2Gb,flat,ekd</td>
<td>The type of disk has implications on performance and occupied space. Values (careful with the case): More information in the VMware documentation.</td>
</tr>
<tr>
<td>VCENTER_ADAPTER_TYPE</td>
<td>Optional</td>
<td>-</td>
<td>vCenter: Possible values (careful with the case): lsILogic, ide, busLogic.</td>
<td>Type of controller to be used with this disk. More information in the VMware documentation.</td>
</tr>
<tr>
<td>READONLY</td>
<td>Optional</td>
<td>-</td>
<td>YES, NO.</td>
<td>This attribute should only be used for special storage configurations. It sets how the image is going to be exposed to the hypervisor. Images of type CDROM and those with PERSISTENT_TYPE set to IMMUTABLE will have READONLY set to YES. Otherwise, by default it is set to NO.</td>
</tr>
<tr>
<td>MD5</td>
<td>Optional</td>
<td>-</td>
<td>An md5 hash</td>
<td>MD5 hash to check for image integrity</td>
</tr>
<tr>
<td>SHA1</td>
<td>Optional</td>
<td>-</td>
<td>An sha1 hash</td>
<td>SHA1 hash to check for image integrity</td>
</tr>
</tbody>
</table>
Warning: Be careful when PATH points to a compressed bz2 image, since although it will work, OpenNebula will not calculate its size correctly.

Mandatory attributes for DATABLOCK images with no PATH set:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE</td>
<td>An integer</td>
<td>Size in MB.</td>
</tr>
</tbody>
</table>

### 7.4.2 Template Examples

Example of an OS image:

```
NAME = "Ubuntu Web Development"
PATH = /home/one_user/images/ubuntu_desktop.img
DESCRIPTION = "Ubuntu 10.04 desktop for Web Development students.
Contains the pdf lessons and exercises as well as all the necessary
programming tools and testing frameworks."
```

Example of a CDROM image:

```
NAME = "MATLAB install CD"
TYPE = CDROM
PATH = /home/one_user/images/matlab.iso
DESCRIPTION = "Contains the MATLAB installation files. Mount it to install MATLAB
on new OS images."
```

Example of a DATABLOCK image:

```
NAME = "Experiment results"
TYPE = DATABLOCK
# No PATH set, this image will start as a new empty disk
SIZE = 3.08
DESCRIPTION = "Storage for my Thesis experiments."
```

### 7.4.3 Restricted Attributes

All the default restricted attributes to users in the oneadmin group are summarized in the following list:

- SOURCE

### 7.5 Image States Reference

This page is a complete reference of all the Image states that will be useful for administrators doing troubleshooting and developers.

The simplified life-cycle is explained in the Virtual Machines Images guide. That simplified diagram uses a smaller number of state names. That section should be enough for end-users and every-day administration tasks.
7.5.1 List of States

OpenNebula’s images define its state using the `STATE` variable. The state can be seen from the CLI (`oneimage show`) and from Sunstone (Info panel for the Image).

<table>
<thead>
<tr>
<th>#</th>
<th>State</th>
<th>Short State Alias</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>INIT</td>
<td>init</td>
<td>Initialization state</td>
</tr>
<tr>
<td>1</td>
<td>READY</td>
<td>rdy</td>
<td>Image ready to use</td>
</tr>
<tr>
<td>2</td>
<td>USED</td>
<td>used</td>
<td>The image is being used by other VM</td>
</tr>
<tr>
<td>3</td>
<td>DISABLED</td>
<td>disa</td>
<td>Image can not be instantiated by a VM</td>
</tr>
<tr>
<td>4</td>
<td>LOCKED</td>
<td>lock</td>
<td>FS operation for the Image in process</td>
</tr>
<tr>
<td>5</td>
<td>ERROR</td>
<td>err</td>
<td>Error state the operation FAILED</td>
</tr>
<tr>
<td>6</td>
<td>CLONE</td>
<td>clon</td>
<td>Image is being cloned</td>
</tr>
<tr>
<td>7</td>
<td>DELETE</td>
<td>dele</td>
<td>DS is deleting the image</td>
</tr>
<tr>
<td>8</td>
<td>USED_PERS</td>
<td>used</td>
<td>Image is in use and persistent</td>
</tr>
<tr>
<td>9</td>
<td>LOCKED_USED</td>
<td>lock</td>
<td>FS operation in progress, VMs waiting</td>
</tr>
<tr>
<td>10</td>
<td>LOCKED_USED_PERS</td>
<td>lock</td>
<td>FS operation in progress, VMs waiting. Persistent</td>
</tr>
</tbody>
</table>

7.6 Host States Reference

This page is a complete reference of all the Host states that will be useful for administrators doing troubleshooting and developers.

The simplified life-cycle is explained in the `Hosts guide`. That simplified diagram uses a smaller number of state names. That section should be enough for end-users and every-day administration tasks.

7.6.1 List of States

OpenNebula’s hosts define its state using the `STATE` variable. The state can be seen from the CLI (`onehost show`) and from Sunstone (Info panel for Hosts).

<table>
<thead>
<tr>
<th>#</th>
<th>State</th>
<th>Short State Alias</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>INIT</td>
<td>init</td>
<td>Initial state for enabled hosts</td>
</tr>
<tr>
<td>1</td>
<td>MONITORING_MONITORED</td>
<td>update</td>
<td>Monitoring the host</td>
</tr>
<tr>
<td>2</td>
<td>MONITORED</td>
<td>on</td>
<td>The host has been monitored</td>
</tr>
<tr>
<td>3</td>
<td>ERROR</td>
<td>err</td>
<td>An error occurs during host monitoring</td>
</tr>
<tr>
<td>4</td>
<td>DISABLED</td>
<td>dsbl</td>
<td>The host was disabled</td>
</tr>
<tr>
<td>5</td>
<td>MONITORING_ERROR</td>
<td>retry</td>
<td>Monitoring the host (from error)</td>
</tr>
<tr>
<td>6</td>
<td>MONITORING_INIT</td>
<td>init</td>
<td>Monitoring the host (from init)</td>
</tr>
<tr>
<td>7</td>
<td>MONITORING_DISABLED</td>
<td>dsbl</td>
<td>Monitoring the host (from disabled)</td>
</tr>
<tr>
<td>8</td>
<td>OFFLINE</td>
<td>off</td>
<td>The host was set offline</td>
</tr>
</tbody>
</table>

7.7 Virtual Network Definition

This page describes how to define a new Virtual Network. A Virtual Network includes three different aspects:

- Physical network attributes
- Address Range
• Configuration attributes for the guests

Note: When writing a Virtual Network template in a file just follows the same syntax as the VM template.

7.7.1 Physical Network Attributes

It defines the **underlying networking infrastructure** that will support the Virtual Network, such as the VLAN ID or the hypervisor interface to bind the Virtual Network.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Value</th>
<th>Mandatory</th>
<th>Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME</td>
<td>Name of the Virtual Network</td>
<td>String</td>
<td>YES</td>
<td>All</td>
</tr>
<tr>
<td>VN_MAD</td>
<td>The network driver to implement the network</td>
<td>802.1Q</td>
<td>YES</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ebtables fw</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ovswitch</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>vxlan</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>vcenter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BRIDGE</td>
<td>Device to attach the virtual machines to, depending on the network driver it</td>
<td>String</td>
<td>YES for dummy, ovswitch,</td>
<td>dummy, 802.1Q</td>
</tr>
<tr>
<td></td>
<td>may refer to different technologies or require host setups.</td>
<td></td>
<td>ebtables fw, vxlan</td>
<td>ovswitch, vcenter</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>vcenter</td>
<td></td>
</tr>
<tr>
<td>VLAN_ID</td>
<td>Identifier for the VLAN.</td>
<td>Integer</td>
<td>YES unless AUTOMATIC_VLAN_ID</td>
<td>802.1Q</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for 802.1Q</td>
<td></td>
<td>vxlan</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>vcenter</td>
</tr>
<tr>
<td>AUTOMATIC_VLAN_ID</td>
<td>If set to YES, OpenNebula will generate a VLAN ID automatically if VLAN_ID is</td>
<td>String</td>
<td>YES unless VLAN_ID for 802.1Q</td>
<td>802.1Q</td>
</tr>
<tr>
<td></td>
<td>is not defined. Mandatory YES for 802.1Q if VLAN_ID is not defined. optional</td>
<td></td>
<td></td>
<td>vxlan</td>
</tr>
<tr>
<td></td>
<td>otherwise.</td>
<td></td>
<td></td>
<td>vcenter</td>
</tr>
<tr>
<td>PHY-DEV</td>
<td>Name of the physical network device that will be attached to the bridge.</td>
<td>String</td>
<td>YES for vcenter</td>
<td>802.1Q</td>
</tr>
</tbody>
</table>

You have more information about the attributes used by the vcenter network driver in the vCenter Network Overview section.

7.7.2 Quality of Service Attributes

This set of attributes limit the bandwidth of each NIC attached to the Virtual Network. Note that the limits are applied to each NIC individually and are not averaged over all the NICs (e.g. a VM with two interfaces in the same network).
### 7.7.3 The Address Range

**IPv4 Address Range**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE IP4</td>
<td>IP4</td>
<td>YES</td>
</tr>
<tr>
<td>IP</td>
<td>First IP in the range in dot notation.</td>
<td>YES</td>
</tr>
<tr>
<td>MAC</td>
<td>First MAC, if not provided it will be generated using the IP and the MAC_PREFIX in oned.conf</td>
<td>NO</td>
</tr>
<tr>
<td>SIZE</td>
<td>Number of addresses in this range.</td>
<td>YES</td>
</tr>
</tbody>
</table>

**IPv6 Address Range**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE IP6</td>
<td>IP6</td>
<td>YES</td>
</tr>
<tr>
<td>MAC</td>
<td>First MAC, if not provided it will be generated.</td>
<td>NO</td>
</tr>
<tr>
<td>GLOBAL_PREFIX</td>
<td>A /64 globally routable prefix</td>
<td>NO</td>
</tr>
<tr>
<td>ULA_PREFIX</td>
<td>A /64 unique local address (ULA) prefix corresponding to the fd00::/8 block</td>
<td>NO</td>
</tr>
<tr>
<td>SIZE</td>
<td>Number of addresses in this range.</td>
<td>YES</td>
</tr>
</tbody>
</table>

**IPv6 Address Range (no-SLAAC)**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE IP6_STATIC</td>
<td>IP6_STATIC</td>
<td>YES</td>
</tr>
<tr>
<td>MAC</td>
<td>First MAC, if not provided it will be generated.</td>
<td>NO</td>
</tr>
<tr>
<td>IP6</td>
<td>First IP6 (full 128 bits) in the range</td>
<td>YES</td>
</tr>
<tr>
<td>PREFIX_LENGTH</td>
<td>Length of the prefix to configure VM interfaces</td>
<td>YES</td>
</tr>
<tr>
<td>SIZE</td>
<td>Number of addresses in this range.</td>
<td>YES</td>
</tr>
</tbody>
</table>

---
Dual IPv4-IPv6 Address Range

For the IPv6 SLAAC version the following attributes are supported:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE</td>
<td>IP4_6</td>
<td>YES</td>
</tr>
<tr>
<td>IP</td>
<td>First IPv4 in the range in dot notation.</td>
<td>YES</td>
</tr>
<tr>
<td>MAC</td>
<td>First MAC, if not provided it will be generated using the IP and the MAC_PREFI in oned.conf.</td>
<td>NO</td>
</tr>
<tr>
<td>GLOBAL_PREFIX</td>
<td>A /64 globally routable prefix</td>
<td>NO</td>
</tr>
<tr>
<td>ULA_PREFIX</td>
<td>A /64 unique local address (ULA) prefix corresponding to the fd00::/8 block</td>
<td>NO</td>
</tr>
<tr>
<td>SIZE</td>
<td>Number of addresses in this range.</td>
<td>YES</td>
</tr>
</tbody>
</table>

The no-SLAAC IPv6 version supports the following attributes:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE</td>
<td>IP4_6_STATIC</td>
<td>YES</td>
</tr>
<tr>
<td>IP</td>
<td>First IPv4 in the range in dot notation.</td>
<td>YES</td>
</tr>
<tr>
<td>MAC</td>
<td>First MAC, if not provided it will be generated using the IP and the MAC_PREFI in oned.conf.</td>
<td>NO</td>
</tr>
<tr>
<td>IP6</td>
<td>First IP6 (full 128 bits) in the range</td>
<td>YES</td>
</tr>
<tr>
<td>PREFIX_LENGTH</td>
<td>Length of the prefix to configure VM interfaces</td>
<td>YES</td>
</tr>
<tr>
<td>SIZE</td>
<td>Number of addresses in this range.</td>
<td>YES</td>
</tr>
</tbody>
</table>

Ethernet Address Range

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Mandatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE</td>
<td>ETHER</td>
<td>YES</td>
</tr>
<tr>
<td>MAC</td>
<td>First MAC, if not provided it will be generated randomly.</td>
<td>NO</td>
</tr>
<tr>
<td>SIZE</td>
<td>Number of addresses in this range.</td>
<td>YES</td>
</tr>
</tbody>
</table>

7.7.4 Contextualization Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NETWORK_ADDRESS</td>
<td>Base network address</td>
<td></td>
</tr>
<tr>
<td>NETWORK_MASK</td>
<td>Network mask</td>
<td></td>
</tr>
<tr>
<td>GATEWAY</td>
<td>Default gateway for the network</td>
<td></td>
</tr>
<tr>
<td>GATEWAY6</td>
<td>IPv6 router for this network</td>
<td></td>
</tr>
<tr>
<td>DNS</td>
<td>DNS servers, a space separated list of servers</td>
<td></td>
</tr>
<tr>
<td>GUEST_MTU</td>
<td>Sets the MTU for the NICs in this network</td>
<td></td>
</tr>
<tr>
<td>CONTEXT_FORCE_IPV4</td>
<td>When a vnet is IPv6 the IPv4 is not configured unless this attribute is set</td>
<td></td>
</tr>
<tr>
<td>SEARCH_DOMAIN</td>
<td>Default search domains for DNS resolution</td>
<td></td>
</tr>
</tbody>
</table>
7.7.5 Interface Creation Options

For 802.1Q, VXLAN and Open vSwitch drivers you can specify parameters in the VNET template. Option can be overridden or added per network.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONF</td>
<td>Driver configuration options</td>
</tr>
<tr>
<td>BRIDGE_CONF</td>
<td>Parameters for Linux bridge creation</td>
</tr>
<tr>
<td>OVS_BRIDGE_CONF</td>
<td>Parameters for Open vSwitch bridge creation</td>
</tr>
<tr>
<td>IP_LINK_CONF</td>
<td>Parameters for link creation</td>
</tr>
</tbody>
</table>

CONF="vxlan_mc=239.0.100.0,test=false,validate_vlan_id=true"
BRIDGE_CONF="sethello=6"
OVS_BRIDGE_CONF="stp_enable=true"
IP_LINK_CONF="tos=10,udpcsum=,udp6zerocsumrx=__delete__"

Options can have empty value when they don’t need a parameter. Also the special value “__delete__” can be used to delete parameters set here.

You can find more information about these parameters in 802.1Q and VXLAN documentation.

7.7.6 Virtual Network Definition Examples

Sample IPv4 VNet:

```bash
# Configuration attributes (dummy driver)
NAME = "Private Network"
DESCRIPTION = "A private network for VM inter-communication"

BRIDGE = "bond-br0"

# Context attributes
NETWORK_ADDRESS = "10.0.0.0"
NETWORK_MASK = "255.255.255.0"
DNS = "10.0.0.1"
GATEWAY = "10.0.0.1"

#Address Ranges, only these addresses will be assigned to the VMs
AR=[TYPE = "IP4", IP = "10.0.0.10", SIZE = "100" ]
AR=[TYPE = "IP4", IP = "10.0.0.200", SIZE = "10" ]
```

Sample IPv4 VNet, using AR of just one IP:

```bash
# Configuration attributes (OpenvSwitch driver)
NAME = "Public"
DESCRIPTION = "Network with public IPs"

BRIDGE = "br1"
VLAN = "YES"
VLAN_ID = 12

DNS = "8.8.8.8"
GATEWAY = "130.56.23.1"
LOAD_BALANCER = 130.56.23.2
```
7.8 Command Line Interface

OpenNebula provides a set commands to interact with the system:

7.8.1 CLI

- **oneacct**: gets accounting data from OpenNebula
- **oneacl**: manages OpenNebula ACLs
- **onecluster**: manages OpenNebula clusters
- **onedatastore**: manages OpenNebula datastores
- **onedb**: OpenNebula database migration tool
- **onegroup**: manages OpenNebula groups
- **onelist**: manages OpenNebula hosts
- **oneimage**: manages OpenNebula images
- **onetemplate**: manages OpenNebula templates
- **oneuser**: manages OpenNebula users
- **onevdc**: manages OpenNebula Virtual DataCenters
- **onevm**: manages OpenNebula virtual machines
- **onevnet**: manages OpenNebula networks
- **onezone**: manages OpenNebula zones
- **onesecgroup**: manages OpenNebula security groups
- **onevcenter**: handles vCenter resource import
- **onevrouter**: manages OpenNebula Virtual Routers
- **oneshowback**: OpenNebula Showback Tool
- **onemarket**: manages internal and external Marketplaces
- **onemarketapp**: manages appliances from Marketplaces

The output of these commands can be customized by modifying the configuration files that can be found in `/etc/one/cli/`. They also can be customized on a per-user basis, in this case the configuration files should be placed in `$HOME/.one/cli`.

List operation for each command will open a **less session** for a better user experience. First elements will be printed right away while the rest will begin to be requested and added to a cache, providing faster response times, specially on big deployments. Less session will automatically be canceled if a pipe is used for better interaction with scripts, providing the traditional, non interactive output.
7.8.2 ECONE Commands

- **econe-upload**: Uploads an image to OpenNebula.
- **econe-describe-images**: Lists all registered images belonging to one particular user.
- **econe-run-instances**: Runs an instance of a particular image (that needs to be referenced).
- **econe-describe-instances**: Outputs a list of launched images belonging to one particular user.
- **econe-terminate-instances**: Shutdowns a set of virtual machines (or cancel, depending on its state).
- **econe-reboot-instances**: Reboots a set of virtual machines.
- **econe-start-instances**: Starts a set of virtual machines.
- **econe-stop-instances**: Stops a set of virtual machines.
- **econe-create-volume**: Creates a new DATABLOCK in OpenNebula.
- **econe-delete-volume**: Deletes an existing DATABLOCK.
- **econe-describe-volumes**: Describe all available DATABLOCKs for this user.
- **econe-attach-volume**: Attaches a DATABLOCK to an instance.
- **econe-detach-volume**: Detaches a DATABLOCK from an instance.
- **econe-allocate-address**: Allocates a new elastic IP address for the user.
- **econe-release-address**: Releases a publicIP of the user.
- **econe-describe-addresses**: Lists elastic IP addresses.
- **econe-associate-address**: Associates a publicIP of the user with a given instance.
- **econe-disassociate-address**: Disassociate a publicIP of the user currently associated with an instance.
- **econe-create-keypair**: Creates the named keypair.
- **econe-delete-keypair**: Deletes the named keypair, removes the associated keys.
- **econe-describe-keypairs**: List and describe the key pairs available to the user.
- **econe-register**: Registers an image.

7.8.3 OneFlow Commands

- **onelfow**: OneFlow Service management.
- **onelfow-template**: OneFlow Service Template management.

7.8.4 OneFlow Commands

- **onegate**: OneGate Service management.