

# Virtual Cluster Manager for Cloud Infrastructure

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**Abstract**—With cloud computing technology, specifically infrastructure as a service (IaaS), it is possible to conveniently deploy a virtual machine on the cloud. There are also a lot of cloud toolkit available to help administrator setup IaaS cloud. However, to deploy a set of virtual machine and configure them to work together as a virtual cluster is still a complicated and tedious task. Most cloud toolkit only individual virtual machine management none offer comprehensive virtual cluster management solution. To address this problem, We propose virtual cluster manager, a unified utility for virtual cluster management. This paper describe design and implementation of virtual cluster manager built on top of existing cloud toolkit as well as the case study of virtual cluster deployment in traditional way compare to using this utility.

## I. INTRODUCTION

With cloud computing[1] being a buzzword recently, there are wide range of cloud computing toolkit available nowadays. Each provides services in different abstraction. In this research, We focus on Infrastructure as a Service[2] (IaaS) paradigm. These tools offer the ability to manage resources ubiquitously with united cloud interface.

Even though virtual infrastructure (VI) provide virtually limitless computation capability to user. In reality, performance of each virtual machine (VM) running on the infrastructure is still limited by physical host machine. It turned out that we have already solved this problem with Cluster Computing. We could use this same methodology and create a cluster of VM instead of physical machine. This technology is called Virtual Cluster[3] (VC).

However, most VI toolkit (such as OpenNebula[4] and Eucalyptus[5]) only focus on individual VM management. Even though it is possible deploy VC with these existing tools by configure and deploy each VM manually, There is no convenient way to manage VC as a whole yet. To simplify this process, We propose a utility which manage VC with existing VI toolkit. This utility will provide to user another layer of abstraction which allow user to view the system as a repository for VC.

In this research, We developed CLI Utility called *onevc* for OpenNebula 3.0 (VI toolkit) which provide the ability to manage VC as a whole. This utility work alongside other built-in CLI utilities seamlessly and provide interface similar to existing built-in utilities for consistency.

Following is the organization of this paper. Section II describes OpenNebula in general and similar utility called “*oneservice*” and differences between “*oneservice*” and this research. Section III describe the architecture of VC manager.

Section IV describe VC manager implementation based-on OpenNebula VI toolkit. Section V show a case study of VC deployment with existing tools compare to using VC manager. Section VI is the conclusion and future improvement ideas.

## II. RELATED WORK

### A. OpenNebula

OpenNebula is VI manager. It orchestrate VM placement, networking and resources such as disk images and expose unified cloud interface to its user, thus create an Infrastructure as a Service (IaaS). It enable creation of private cloud with existing resources. OpenNebula also feature its modular architecture which allow it to work with wide range of hypervisor. This feature also enable OpenNebula to support creation of hybrid cloud as well.

### B. oneservice

There is a concept of service which consist of multiple VM working together being developed for OpenNebula. For an example a web server service could consists of web servers, database servers and load-balancers. *oneservice*[6] utility allow user to describe service and its dependencies with Service Description Language (SDL). This idea is similar to the virtual cluster but the key difference is service management allow user to manage as group of virtual machine as a whole while virtual cluster management allow user to manage the whole cluster or just a subset of machines in the cluster.

## III. ARCHITECTURE

Similar to how *onevm* works, to describe a VC to *onevc* utility, We use hierarchical template system. This template system allow user to describe VC attributes in one single template file. This template extend existing VM template system by introducing template for VC. *onevc* utility take VC template as an input and register the VC to database. After that, user can instruct *onevc* to do management operations on registered VC or each VM type individually. Supported management operations are create, deploy, suspend, stop, resume, delete, list and show.

### A. Virtual Cluster Model

In this research, We define VC with a hierarchical model. A VC consists of one or multiple VM Type, served as a grouping method for VM. A number of VM could be instantiate in each VM type. Figure 1 shows hierarchy of VC in this model.

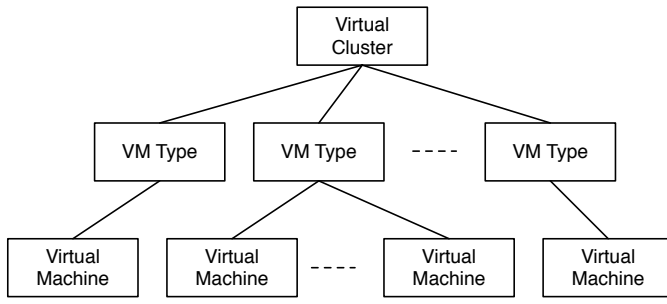


Fig. 1. Hierarchical Model of Virtual Cluster

VM types in VC also forming it own hierarchy. We use this hierarchy along with other configurations to determine deployment order of each VM in a VC.

One example is a VC with one frontend machine and a number of compute node. To represent this VC with this model, We use 2 VM type to represent frontend VC and compute node VM. frontend VM type contains only one VM while compute nodes VM type contains n number of VM with compute nodes VM type being a child of frontend VM type.

### B. Virtual Cluster Template

To describe VC with my model, We use template. For each VC, a VC template is used to describe its properties. This VC template syntax is the same with OpenNebula template syntax to preserve consistency with others built-in utilities, to be more familiar to user. VC properties may include information such as name, VC types and number of VM to deploy for each VM type.

To describe each VM type in VC template, we use the same OpenNebula VM template structure. We also allow pointing to external VM template path or template id of template registered in onetemplate built-in utility. If VC template is defined with either of this 2 methods, we also allow VM type template overriding from VC template as well. This allows VM type sharing between many VC template as we could modify VC specific configuration such as networking as needed.

Each VM type is also configurable with external deployment policy such as “with parent”, “after parent” or “manual” and internal deployment policy such as “all together” or “one by one”. These policies will be use to determine deployment order of each VM for automatic cluster deployment. See figure 2 for an example of Rocks Cluster VC template

To determine deployment order, firstly, we use external deployment policy and VM type hierarchy to determine deployment order of VM type. VM type that don’t have parent will be deploy first. If there are any child VM type of these VM which external deployment policy set to “with parent”, those VM type will be deploy at the same time. After all of these VM type successfully deployed (reached “running” state), their childs will be deploy next, and so on until all VM type is deployed. For deployment order of each machine in the same VM type, we use internal deployment policy.

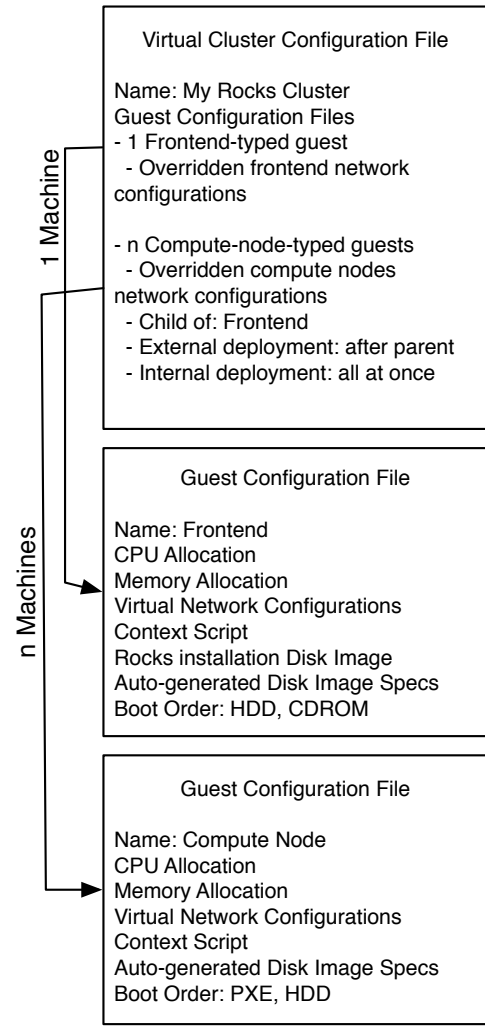


Fig. 2. Example VC template (detail omitted)

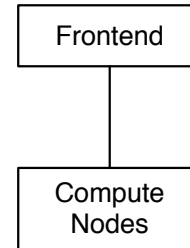


Fig. 3. VM Type Hierarchy of Example VC template

### C. Virtual Cluster State

We assign state to each VM type in a VC and the VC itself in order to keep tracking. During initialization, all VM type will be assigned to “pending” state. State of VM type is shifted along with VC management operations (deploy, suspend, resume, etc.). State shifting is described in figure 4. These states was designed to support OpenNebula’s VM state[7] and bear a similarity with it. In a sense, they are like a simplify version or OpenNebula’s VM state.

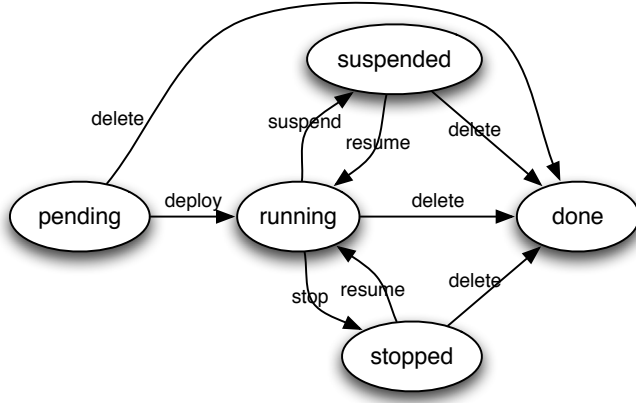


Fig. 4. VC and VM type state diagram

When all VM type in a VC is in the same state, VC itself is assigned with that state as well. Otherwise, the VC is assigned “shift” intermediate state to indicate that the state is being shifted and currently inconsistent.

#### IV. IMPLEMENTATION

User supply VC template to `onevc` in the same fashion as with `onevm` utility. `onevc` will then validate the template, put it into `onevc` database and assign all VM type and the VC itself with “pending” state. After that, `onevc` will create all VC with OpenNebula and put all of them in OpenNebula’s “pending” state, waiting for deployment. User could then deploy registered VC and do management tasks with `onevc` utility.

`onevc` utility support these operations.

- `create` register VC template to `onevc` utility and initialize VC
- `deploy` specify VC or specify VM type according to VM type hierarchy and deployment policy in VC template
- `suspend` suspend VC or specify VM type in reverse order of deployment
- `stop` stop VC or specify VM type in reverse order of deployment
- `resume` resume VC or specify VM type in the same order as deployment
- `delete` delete VC or specify VM type in reverse order of deployment
- `list` list registered VCs and their statuses
- `show` show specify VC information

#### V. CASE STUDY

Using the example VC template in Figure 2, We deploy the VC with existing utility and `onevc` utility.

##### A. With existing built-in utility

Firstly, We created 2 templates for frontend and compute nodes and register it to `onemplate` built-in utility with this command.

```
$ onemplate create
<path_to_templatefile>
```

Then, We instantiate 1 frontend VM follow by a number of compute node. To instantiate VM with `onemplate`, We used this command.

```
$ onemplate instantiate <template_id>
```

Where `<template_id>` is one template’s template id given to registered template. It took 2 commands to register template, 1 command to instantiate frontend and 1 command to instantiate each compute node so We used 3+n commands in total. We also need to maintain each template individually and make sure that configurations in both template worked together.

##### B. With `onevc` utility

Let the name of VC configuration file is `myrockcluster.one`, Firstly, user need to register the template with this command

```
$ onevc create myrockcluster.one
```

After registration, user can use this command.

```
$ onevc deploy myrockcluster
```

According to deployment policies in the template, `onevm` will deploy frontend VM first. After it reach “running” state, it will deploy n number of compute nodes at once. User can choose to deploy each VM type manually by using these following commands.

```
$ onevc deploy myrockcluster frontend
```

```
$ onevc deploy myrockcluster
computenodes
```

Note that if frontend VM type isn’t at “running” state when user manually deploy compute nodes then `onevm` will try to move frontend to “running” state by deploying or resuming as necessary.

In total, We used 2 commands for automatic deployment and 3 commands for manual VM type deployment regardless of how many compute nodes are there in the cluster.

#### VI. CONCLUSION AND FUTURE WORK

In this paper, we describe a convenient utility for VC management with existing VI toolkit. Instead of management each VM in a VC individually, this utility offers a method to manage VC as a whole. In order to flexibly describe VC, We use hierarchical VC model along with the template system. This template system also offer policy configurations which to be used alongside VM type hierarchy to determine deployment order. With this architecture, We implemented `onevc` utility for OpenNebula and show how to deploy typical VC with this tool compare with existing built-in utility. It is clear from the result that this utility made VC management simpler.

However, We only look into VC management and leave VC template management totally to user. For this issue, We could create another utility to manage VC template. This utility could work in the same manner as `onemplate` built-in utility of OpenNebula manage VM template but with VC template instead.

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