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A State-of-art Comparison of Opensource IaaS Cloud Softwares

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Abstract: *Most of the organizations are looking for deployment of Infrastructure-as-a-service (IaaS) cloud for its benefits. However with many opensource IaaS cloud softwares available in market, to choose right one is difficult. It is important to understand IaaS cloud software's architecture, technology and suitability with existing infrastructure. This manuscript compares a state-of-art of most popular opensource IaaS cloud softwares such as Openstack, CloudStack, Eucalyptus and Opennebula. The motive is to help organizations to determine which solution meets their requirements.*

Keywords: *Comparison cloud management softwares, OpenStack, CloudStack, OpenNebula, Eucalyptus cloud software*

I. Introduction

A recent 2014 survey indicates cloud adoption by the enterprises continues unabated to about 94%[1]. These organisations are either running their applications on cloud or have started building their own cloud. Some of the popular commercial IaaS providers are Amazon Web Services(AWS), GoGrid, Microsoft Azure, Google Compute Engine, IBM Smart Cloud, Rackspace Open Cloud, HP enterprise converged infrastructure. These providers own infrastructure and rent computing resources to consumers on pay-as-you-go basis. This model of computation known as "public cloud" computation is suitable for start-up companies, individual project developers and organization having shortage of resources as they need not invest in the infrastructure. However public cloud has its own drawbacks such as security[2] and cost of rent. Most of the enterprises which have existing infrastructure and want to leverage the benefits of cloud can opt for building their own cloud environment i.e "private cloud". Further enterprises having their "private cloud" can draw additional resources when required from the "public cloud" providers by constructing a "hybrid cloud". A Cloud Management Software(CMS) is required to build the cloud environment which provides the functionality of creating, provisioning and managing of virtual machines known as Infrastructure-as-service(IaaS) cloud. There are commercial vendor who build and support cloud infrastructure but one of the viable option would be to use opensource CMS and build own cloud. The open source software has its own advantages such as no license cost, strong user and developer community, innovative technology, quick release cycles, open standards i.e no vendor lock-in, transparency and they are based on the real world generic business needs. Some of the opensource CMS available for building cloud infrastructure are Nimbus, Abicloud, OpenStack, OpenNebula, Eucalyptus and CloudStack. Thus enterprises can use freely available open source CMS and efficiently utilize the existing infrastructure by creating their own private cloud, further expand their horizon by building a hybrid cloud. This is motivating enterprise, universities towards opensource CMS, but the difficulty is to select form the many available CMS. According to survey[3] Openstack is the most popular CMS followed by CloudStack, Opennebula and then Eucalyptus. Hence this manuscript presents simple and easy to understand the state-of-art of these four CMS. It provides comparison in terms of their architecture and features. The motive is to aid the decision of choosing CMS based on the requirements and compatibility with existing infrastructure.

II. Literature Survey

Cloud computing is emerging technology with intense ongoing research on various aspects. Some research has been done on defining criteria to be used for comparing opensource CMS[4][5] and some existing opensource CMS have been compared [6][7][8][9][10]. This section briefly outlines the previous research work done and discusses the additional contribution by this study.

Ivan Voras[4] discusses set of criteria to be used for comparison and evaluation of open source IaaS cloud computing solutions. The criteria are grouped into six major categories: storage, virtualization, network, management, security and vendor support. However the criteria defined are abstract and does not include many of the features of present day CMS such as fault tolerance, monitoring, load balancing, compatibility, interoperability etc. Stefan Wind[6] provided comparison of the four open source CMS - Eucalyptus, Abicloud, OpenNebula, Nimbus using set of generic criteria and provides recommendations for use. The study[6] says that - Euclyptus, Open Nebula and Abicloud are suitable for enterprises, universities and scientific computations but

Nimbus has user interface typically suited for scientific domain and requires user orientation. Xiaolong Wen[7] provides comparison of OpenStack and OpenNebula from provenance, architecture, hypervisor, security and other aspects. Based on the comparison it is suggested that OpenStack is an opensource alternative for EC2, S3 and OpenNebula is suited for large data centers. Patricia Takako Endo[8] discusses the challenges faced by the developers in implementing the cloud solutions, efforts in standardizing the interfaces for interoperability and finally provides comparison between set of open source cloud computing platforms. The author[8] concludes there is need for standardization of cloud platforms. Peter Simpolinski[9] provides a brief feature set comparison of Eucalyptus, OpenNebula and Nimbus and analyse how the differing architectures suite different goals. Further the author[9] discusses the challenges in setting up these platforms and suggests the scope for further research and development. Arpit Malani[5] provides taxonomy of cloud features to be used for comparison, then provides a comparison between some open source cloud such as OpenStack, Opennode, CloudStack, P romox, OpenNebula, Eucalyptus and OpenQRM . Omar Sefraoui[10] discusses OpenStack solution in detail and a brief comparison with Eucalyptus and OpenNebula in terms of support for new standards. OpenStack supports Open Cloud Computing Interface(OCCI) through Open Grid Forum(OGF)[11]. OCCI is set of open-community lead specifications through OGF. OpenStack has also proposed support for OpenFlow standard [12].

III. CMS Architecture

This section briefly discusses architecture of CMSs under study. It introduces the basic components of the CMS software and how they interact. This helps in comprehending functioning of CMSs under study better. However the comprehensive features of each CMS are listed in the table 2.

A. Openstack Architecture

Openstack is the most popular among the opensource CMSs[3]. The objective of openstack is to produce the ubiquitous opensource cloud computing platform that will meet the needs of public and private clouds regardless of size, by being simple to implement and massively scalable[13]. Openstack has got various services developed under different projects. These projects are integrated to provide complete functionality of Openstack. The descriptions of various services and projects of Openstack are discussed in table 1.

Table 1 OpenStack Services and Projects

Services	Project Name	Description
Dashboard	Horizon	Web Based self service
Compute	Nova	Manages the lifecycle of compute instances
Networking	Neutron	Provides network connectivity as service for openstack service
Storage		
Object storage	Swift	Stores and retrieves unstructured data objects via RESTful API, HTTP based API
Block storage	Cinder	Provides persistent block storage to running instances
Shared Services		
Identity Services	Keystone	Provides authentication and authorization for open stack services
Image Service	Glance	Stores and retrieves VM disk images
Telemetry	Celiometer	Monitors and metering service for billing, scalability, benchmarking and statistical purpose.
Higher-level Service		
Orchestration	Heat	Orchestration of multiple composite cloud applications
Database service	Trove	Database service for relational and non-relational database engines

The interaction between the Openstack components is as shown in figure 1.

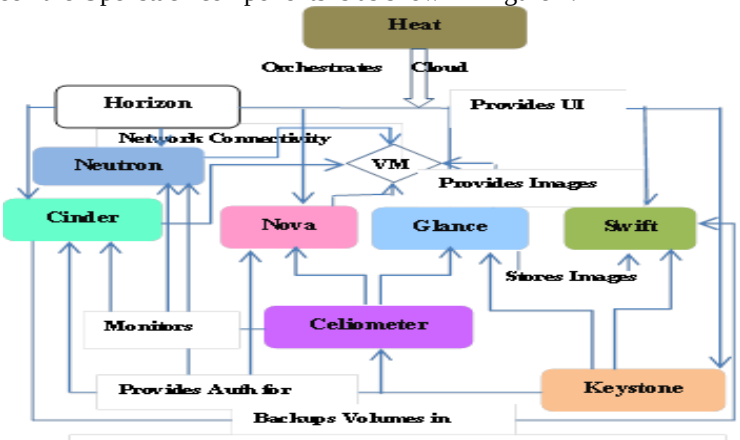

Figure 1: OpenStack Conceptual Architecture

B. CloudstackArchitecture

CloudStack is gaining momentum in the opensource CMS market. The objective of CloudStack is to deploy and manage large networks of virtual machines, as highly available, highly scalable IaaS cloud computing platform[14]. The CloudStack deployment architecture is shown in figure 2. It consists of two parts: Management server and Cloud infrastructure.

The management server is CloudStack software that manages the resources provisioned like hosts, storage and IP address. It runs on a dedicated server(s) or VM and is used to configure and manage the cloud infrastructure.

A typical CloudStack infrastructure organisation is as shown in figure 3. It consists of

- Zone: a single datacentre consisting of pods and secondary storage
- Pod: One rack of hardware consisting of layer-2 switch and cluster(s)
- Cluster: one or more hosts and primary storage
- Hosts: A single compute node within which cloud services run
- Primary storage: stores the disk volumes for all VMs running on hosts in that cluster
- secondary storage: stores templates, ISO images and disk volume snapshots.

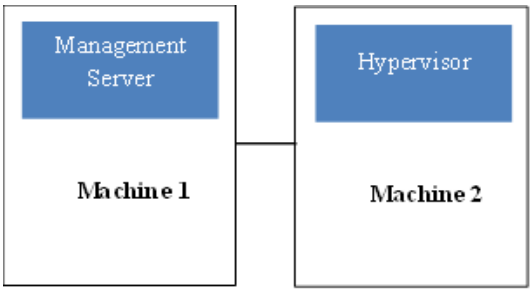

Figure 2: Cloudstack Deployment Architecture

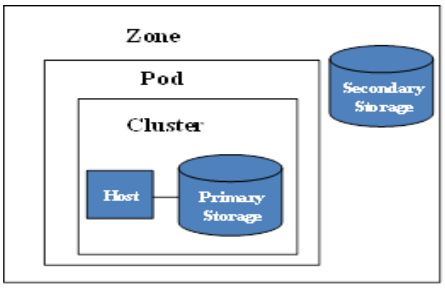

Figure 3: Nested Organization of Zone

C. Eucalyptus Architecture

Eucalyptus is an AWS compatible opensource CMS. The objective of Eucalyptus is to provide private and hybrid cloud that is Amazon Web Services (AWS) compatible and to ensure fast and secure access to mission-critical data[15]. Eucalyptus has highly scalable distributed architecture with six components at three levels. The figure 4 shows the eucalyptus architecture.

i. Cloud level

- Cloud Controller(CLC): It is a query and web interface to outside world. It is an administrative interface and handles high level authentication, system accounting, quota management and reporting.
- Scalable Object Storage(SOS): It is Eucalyptus's storage service. The basic implementation known as Walrus is suitable for evaluation and small cloud deployments. It is pluggable service that can be extended with dedicated storage solutions.

ii. Cluster level

- Cluster controller: Eucalyptus can have multiple clusters and CC acts as frontend for the cluster. It communicates with the SC and NC and manages the execution of VMs and SLAs per cluster. It is equivalent to AWS availability zone.
- Storage controller: It manages block volumes and snapshots mapped to VMs within a cluster. It communicates with CC and NC and interfaces with storage systems local, NFS, iSCSI and SAN. It is equivalent to AWS Elastic Block Storage(EBS).

iii. Node level

- Node Controller (NC): It hosts VMs and manages virtual network endpoints. It downloads and caches the images from the Object Storage and creates and caches the VM instances.

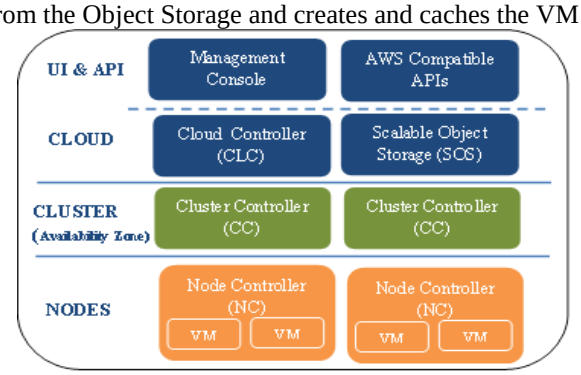

Figure 4: Eucalyptus Architecture

D. OpenNebula Architecture

Opennebula is opensource CMS suited for managing virtualized datacenter. The objective of Opennebula is to provide an open flexible, extensible and comprehensive management layer to automate and orchestrate the operation of enterprise cloud by leveraging and integrating existing deployed solutions for networking, storage, virtualization, and monitoring or user management[16].

The figure 5 below shows the Opennebula architecture. The basic components of Openbula are:

i. Front end that executes open nebula services
ii. Hypervisor enabled hosts that provide resources needed by VMs
iii. Datastores that stores base images of VMs.
iv. Physical networks used to support basic services such as interconnection of storage servers and OpenNebula control operations and VLANs for VMs.

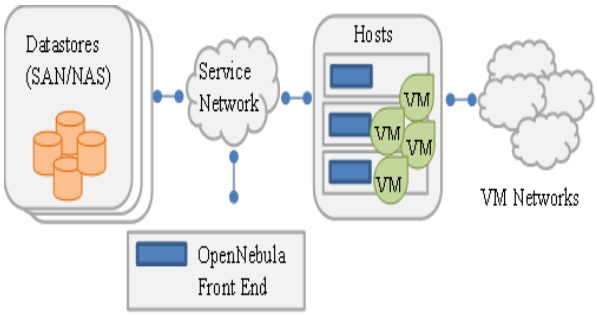

Figure 5: OpenNebula Conceptual Architecture

IV. Comparision of Cloud Management Softwares

On the basis of the work done previously [3-9] following set of features are used for comparison of OpenStack, Eucalyptus, OpenNebula and CloudStack. The set of features includes: latest software release, opensource license, programming language, database support, cloud type support, installation difficulty, architecture, compatibility with public cloud, hypervisor support, Operating system support, official website, community website, and key new features of the software. The following table 2 gives comparison of Eucalyptus, OpenNebula, CloudStack and OpenStack CMS.

Table 2 Comparison of OpenStack, Eucalyptus, OpenNebula and CloudStack CMS

	Openstack	Eucalyptus	Opennebula	CloudStack
First release	21 October,2010	01 may, 2008	01 March, 2008	06 November, 2012
Latest release	Openstack Juno 2014.2 October 16, 2014	Eucalyptus 4.0.2 October 20, 2014	OpenNebula 4.10.1 Nov 20,2014 Maintenance release	Apache CloudStack 4.4.0 October 23,2014 (bugfix release)
Programming Language	Python	C and Java	C, C++, Java Script, Ruby	Java 1.7
Components	Nova, Glance, Keystone, Cinder, Horizon, Neutron	CLC, SC, CC, Walrus, NC	Frontend Host, Image Repository, Physical network	Compute, Network, Storage
License	Apache V2.0	GPL V3.0	Apache V2.0	Apache V2.0
Installation difficulty	Difficult	Easy	Easy	Medium level
Cloud Type	Private, public and hybrid	Private and hybrid	Private,public, hybrid	Public, private, hybrid
Hypervisor	KVM, LXC, QEMU, UML, VMWare VSphere update 1 and newer , Citrix Xenserver, Xen Cloud Platform and Baremetal service via pluggable sub drivers	Xen for CentOS 5 and RHEL 5, KVM for CentOS 6, RHEL 6 and Ubuntu, VMware's ESX	Xen, KVM, VMware	VMware, KVM, XenServer, Xen Cloud Platform(XCP) and Hyper-V.
Operating System Support	Red Hat Enterprise Linux 3, Linux 4, Linux 5 , Linux 6 (32 bit and 64 bit) Windows XP Service Pack 3 and newer (32 bit only),Windows 7 (32 bit and 64 bit), Windows 8 (32 bit and 64 bit), Windows Server 2003 Service Pack 2 and newer (32 bit and 64 bit), Windows Server 2008 (32 bit and 64 bit), Windows Server 2008 R2	GNU/Linux, VM's can host windows/Linux	Windows and Linux	Windows, Linux and various versions of BSD.

	Openstack	Eucalyptus	Opennebula	CloudStack
Architecture	Fragmented architecture- every openstack component is individual project	Monolithic	Monolithic	Monolithic
Public cloud compatibility	Amazon EC2 and Amazon S3	AWS	Microsoft Azure, AWS	AWS EC2 and S3
Database Support	RabbitMQ, MySQL, MongoDB, MariaDB	PostgreSQL	SQLite or MySQL	MySQL
Community	OpenStack	Eucalyptus	Opennebula	Apache CloudStack
Website	http://www.openstack.org/	http://www.eucalyptus.com/	http://opennebula.org/	http://CloudStack.apache.org/
Logo				

V. Conclusion

From the comparative study it is inferred that Openstack, CloudStack, Eucalyptus and Opennebula opensource CMS can be used to IaaS cloud orchestration. Openstack although difficult to install has got strong user and developer community support to guide the installation process. Openstack - juno key new feature includes support to bigdata analytics and telecommunication networking, which are current need of market. CloudStack has medium level difficulty of installation process and easy-to-use interface. CloudStack has been recently launched and still evolving. The strength of Eucalyptus is AWS compatibility. It is interoperable with the AWS, which is the leading public cloud provider. So if hybrid cloud is the future plan then Eucalyptus is preferable option for an organisation. Opennebula is basically for extension of datacentre virtualization. If enterprise has datacenter and is looking for a tool to orchestrate and manage the datacentre then opennebula is preferred option. However the final conclusion would be that Openstack is currently dominating the opensource CMS market and with its rapid developments addressing the market needs.

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