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Comparative Study of Open Nebula, Eucalyptus, Open Stack and Cloud Stack

Hiren Parmar
L. D. C. E, GTU
India

Tushar Champaneria
Assistant Professor, L. D. C. E, GTU
India

Abstract – Presently, many cloud Infrastructure as Service(IaaS) platforms exist. Cloud Consumer, Developer and Cloud Providers needs to make decision about which platform is well suited for them. Since, last decades open-source technology help people who do not wish to use commercial infrastructure for cloud. Among them different open-source platform OpenNebula, Eucalyptus, OpenStack and CloudStack are the platform which have been majorly used cloud management platform (CMP) and also alternatives of commercially provided cloud. Here, we compare and analyzing OpenNebula, Eucalyptus, OpenStack and Cloudstack platform. These all CMP's are providing IaaS (infrastructure as a Service). In this paper we start with short summary of feature set of these projects. And after that we do detailed analysis of different software packages and describe how these cloud management platforms (CMP) relate to other CMP's. Here, we also analyze overall architecture of cloud management platforms (CMP) and refer differing features.

Keywords–OpenNebula, Eucalyptus, OpenStack, CloudStack, Cloud Management Platforms (CMP)

I. INTRODUCTION

NIST definition, "cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."[5]

There are basically below mentioned three kind of services provided by cloud computing platforms :

1. Iaas (Infrastructure as a Service)
2. PaaS (Platform as a Service)
3. SaaS (Software as a Service)

IaaS Definition Infrastructure as a service (IaaS) is a standardized, highly automated offering, where compute resources, complemented by storage and networking capabilities are owned and hosted by a service provider and offered to customers on-demand. Customers are able to self-provision this infrastructure, using a Web-based graphical user interface that serves as an IT operations management console for the overall environment. API access to the infrastructure may also be offered as an option.[6]

PaaS Definition A platform as a service (PaaS) offering, usually depicted in all-cloud diagrams between the SaaS layer above it and the IaaS layer below, is a broad collection of application infrastructure (middleware) services (including application platform, integration, business process management and database services). However, the hype surrounding the PaaS concept is focused mainly on application PaaS (aPaaS) as the representative of the whole category.[7]

SaaS Definition Gartner defines software as a service (SaaS) as software that is owned, delivered and managed remotely by one or more providers. The provider delivers software based on one set of common code and data definitions that is consumed in a one-to-many model by all contracted customers at anytime on a pay-for-use basis or as a subscription based on use metrics.[8]

Here, in this paper we only concentrate on IaaS Platform. Single processor can't perform heavy computation efficiently. For heavy computational jobs we require hundred or even thousands of cores, different paradigms have been developed for harnessing the computation power of large group of processors. The two biggest project LHC (Large Hydrogen Collider)[9] and SGE(Sun Grid Engine)[10] have their own infrastructure for IaaS platform and require very high computation of data.

Commercial cloud management platform (CMP) will charge based on by the hour, for CPU time, for storage requirement, for network bandwidth. If organization having large number of users, it is better to purchase their own hardware and create private cloud. And here open-source cloud management platform OpenNebula[1], Eucalyptus[1], OpenStack[3], and CloudStack[4] comes into the scene. These are the cloud management platform (CMP) which allows organization to set their group of machines as private cloud. In this paper, we analyze four open-source cloud management platforms (CMP) mainly because of different point of interest in their design.

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II. GENERIC ARCHITECTURE OF CLOUD COMPUTING PLATFORM

In generic architecture of cloud computing system we have six basics components

1. Hardware & Operating System

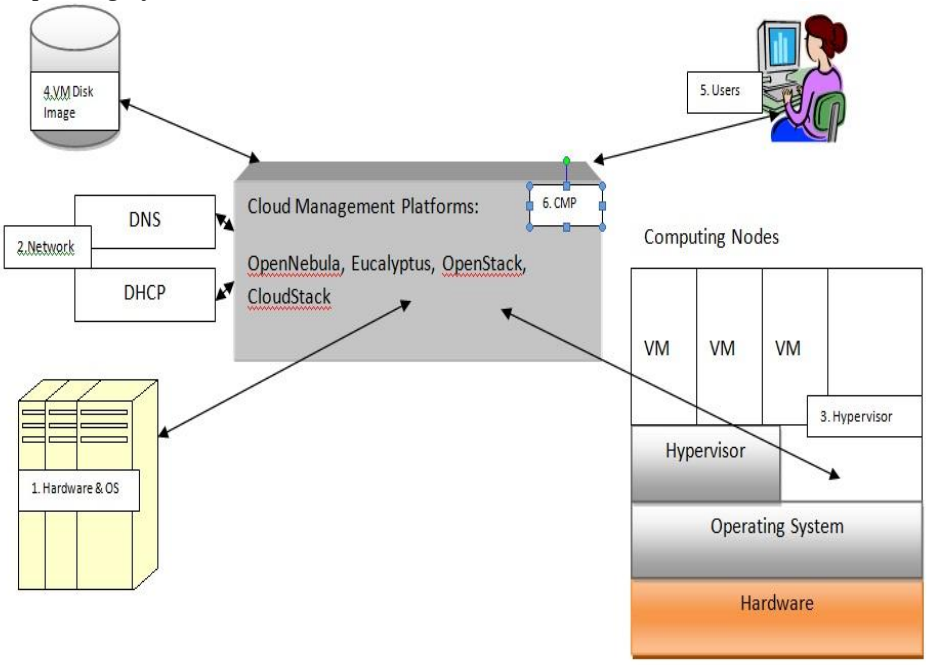

Figure 1 Generic Architecture of Cloud Management Platforms

2. Network includes DNS, DHCP & Subnet organization of the physical machines and it depends based on different cloud management platforms.
3. Hypervisors. Sits between operating system & virtual machines. Different types of hypervisors are Xen, KVM & VMWare etc.
4. VM Disk Images
   - Template Disk Images : Used for creating multiple VMs on the cloud platform.
   - Run-time Images : Actually used by Virtual Machines at run-time.
5. Front-end user interface. There are basically two types of interfaces Cloud provider/administrator and cloud consumer are those who request for virtual machines.
6. Cloud Management Platforms (CMPs) like OpenNebula, Eucalyptus, OpenStack, CloudStack. The CMP provides the interface at the front-end, uses the disk images from the repository signals VMM(Virtual Machines Manager) to set up VM & then signals DHCP & IP Bridging program to setup MAC & IP address for the VM.

III. OVERVIEW OF OPENNEBULA, EUCALYPTUS, OPENSTACK AND CLOUDSTACK

A. *Opennebula*

OpenNebula is an open source manager of virtual infrastructure [1], able to build private, public and hybrid clouds. OpenNebula offers flexible architecture, interfaces and components that could be integrated into any data center. This tool supports Xen, KVM and VMware and access to Amazon EC2s.

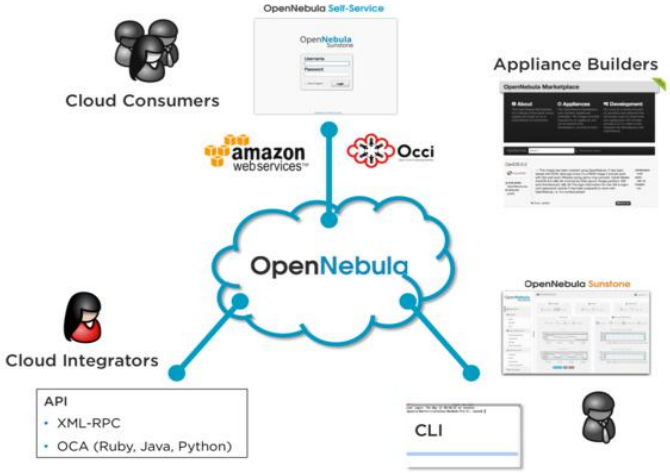

Figure 2 OpenNebula Architecture

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OpenNebula was designed to be integrated into any network and storage solution. OpenNebula manages the storage, networking and virtualization technologies to enable the establishment of dynamic multi-level services (groups of interconnected virtual machines) on the distributed infrastructure, combining the resources of physical machines and cloud distance, based allocation policies OpenNebula consists of three components [14]: core (Virtual Infrastructure Manager): Manages the lifecycle of the virtual machine by running the basic operations (deployment, monitoring, migration).

B. *Eucalyptus*

Eucalyptus commands can manage either Amazon or Eucalyptus instances. Users can also move instances between a Eucalyptus private cloud and the Amazon Elastic Compute Cloud[11] to create a hybrid cloud. Hardware virtualization isolates applications from computer hardware details.[12]

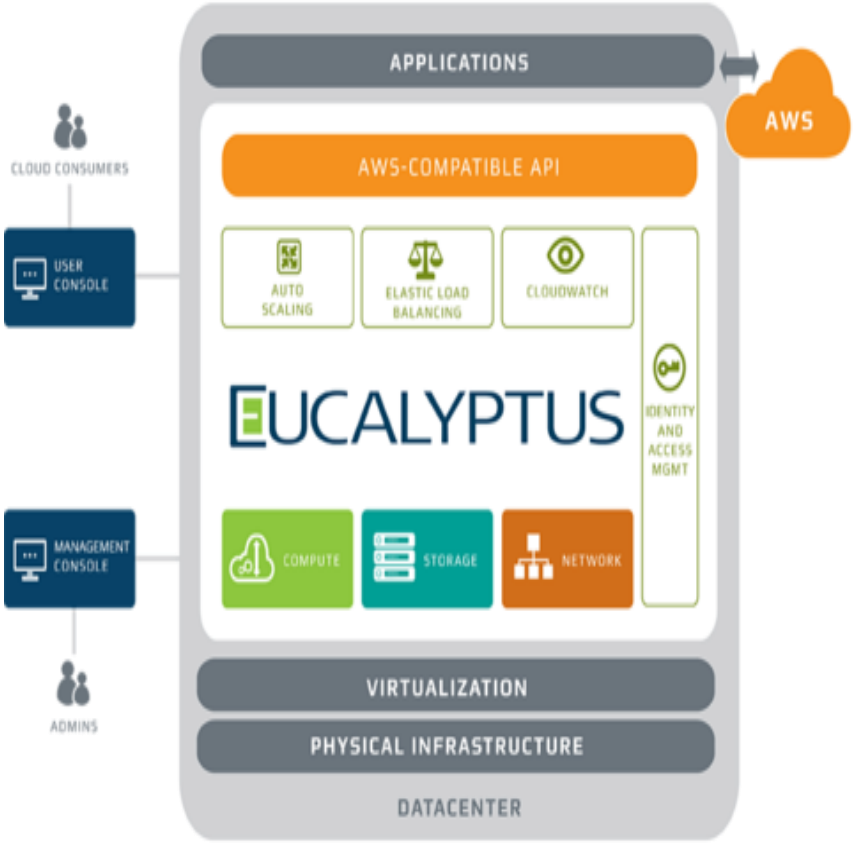

Figure 3 Eucalyptus Architecture

Eucalyptus uses the terminology:[13]

- Images – An image is a fixed collection of software modules, system software, application software, and configuration information that is started from a known baseline (immutable/fixed). When bundled and uploaded to the Eucalyptus cloud, this becomes a Eucalyptus machine image (EMI).
- Instances - When an image is put to use, it is called an instance. The configuration is executed at runtime, and the Cloud Controller decides where the image will run, and storage and networking is attached to meet resource needs.
- IP addressing - Eucalyptus instances can have public and private IP addresses. An IP address is assigned to an instance when the instance is created from an image. For instances that require a persistent IP address, such as a web-server, Eucalyptus supplies elastic IP addresses. These are pre-allocated by the Eucalyptus cloud and can be reassigned to a running instance.
- Security - TCP/IP security groups share a common set of firewall rules. This is a mechanism to firewall off an instance using IP address and port block/allow functionality. At TCP/IP layer 2 instances are isolated. If this were not present, a user could manipulate the networking of instances and gain access to neighboring instances violating the basic cloud tenet of instance isolation and separation.
- Networking - There are three networking modes. In Managed Mode Eucalyptus manages a local network of instances, including security groups and IP addresses. In System Mode, Eucalyptus assigns a MAC address and attaches the instance's network interface to the physical network through the Node Controller's bridge. System Mode does not offer elastic IP addresses, security groups, or VM isolation. In Static Mode, Eucalyptus assigns IP addresses to instances. Static Mode does not offer elastic IPs, security groups, or VM isolation.
- Access Control - A user of Eucalyptus is assigned an identity, and identities can be grouped together for access control.

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C. ***OpenStack [15]***

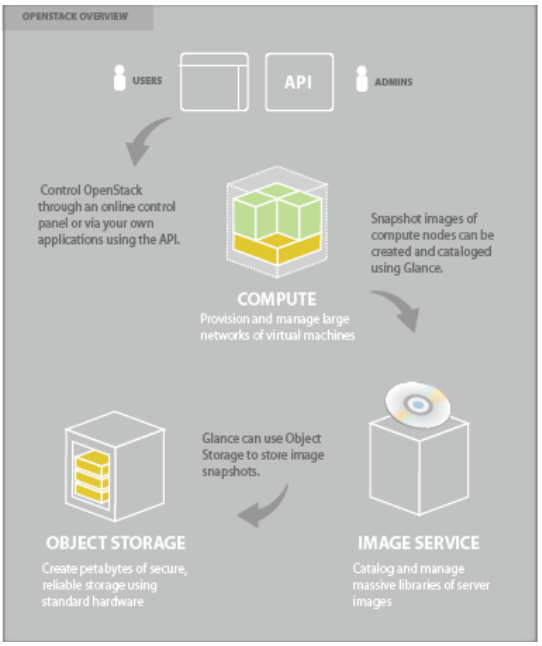

Figure 4 OpenStack Architecture

OpenStack is a global collaboration of developers and cloud computing technologists producing the open standard cloud operating system for both public and private clouds. Cloud service providers, enterprises and government organizations can take advantage of the the freely available, Apache-licensed software to build massively scalable cloud environments. OpenStack currently consists of three core software projects: OpenStack Compute (code-name Nova), OpenStack Object Storage (code-name Swift), and OpenStack Image Service (code-name Glance). These projects, along with a vibrant ecosystem of technology providers and future OpenStack projects underway, deliver a pluggable framework and operating system for public and private clouds.

D. ***CloudStack [16]***

A CloudStack installation consists of two parts: the Management Server and the cloud infrastructure that it manages.

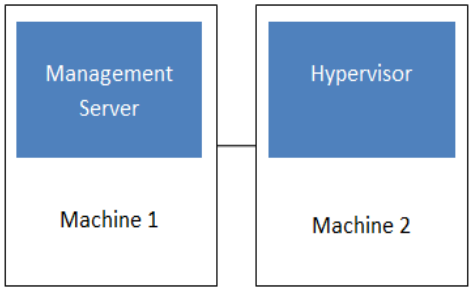

Figure 5 Simplified View of Basic Deployment

Management Server Overview :

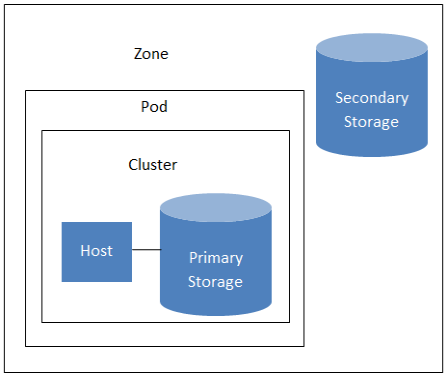

Figure 6 Nested Organization of Zones

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- Provides the web user interface for the administrator and a reference user interface for end users.
- Provides the APIs for CloudStack.
- Manages the assignment of guest VMs to particular hosts.
- Manages the assignment of public and private IP addresses to particular accounts.
- Manages the allocation of storage to guests as virtual disks.
- Manages snapshots, templates, and ISO images, possibly replicating them across data centers.
- Provides a single point of configuration for the cloud.

Cloud Infrastructure Overview:

- Zone: Typically, a zone is equivalent to a single datacenter. A zone consists of one or more pods and secondary storage.
- Pod: A pod is usually one rack of hardware that includes a layer-2 switch and one or more clusters.
- Cluster: A cluster consists of one or more hosts and primary storage.
- Host: A single compute node within a cluster. The hosts are where the actual cloud services run in the form of guest virtual machines.
- Primary storage is associated with a cluster, and it stores the disk volumes for all the VMs running on hosts in that cluster.
- Secondary storage is associated with a zone, and it stores templates, ISO images, and disk volume snapshots.

IV. COMPARISON OF OPENNEBULA, EUCALYPTUS, OPENSTACK, CLOUDSTACK [17]

Based on Cloud Computing Perspectives

1. Developer Perspective
   - Development Model
   - Development Engagement
   - Governance Model
2. User Perspective : There will be two types of user perspective one is from the "Cloud Consumer" and other is "Cloud Builder"
   - API Ecosystem
   - Production Readiness

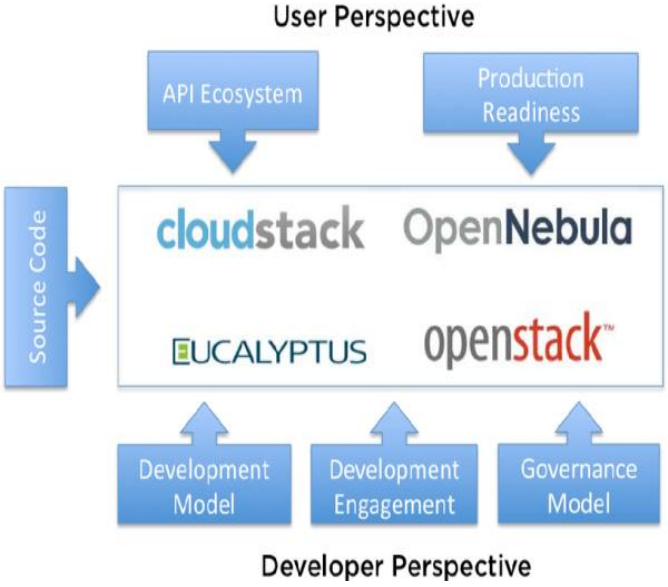

Figure 7 Cloud Computing Perspective

TABLE 1 CLOUD COMPUTING USER PERSPECTIVE

	OpenStack	**CloudStack**	**Eucalyptus**	**OpenNebula**
Development Model	Public development	Public development	Public development	Public development
Developer Engagement	Contributor license agreement	Contributor license agreement	Contributor license agreement	Contributor license agreement
Governance Model	Foundation	Technical meritocracy	Benevolent dictator	Benevolent dictator

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TABLE 2 CLOUD COMPUTING DEVELOPER PERSPECTIVE

	OpenStack	**CloudStack**	**Eucalyptus**	**OpenNebula**
API Ecosystem	OpenStack API	Amazon API	Amazon API	Amazon API
Production Readiness	No, only available through any of the several vendor specific "stacks"	Enterprise-ready and direct support from developers	Enterprise-ready and direct support from developers	Enterprise-ready and direct support from developers

Based on Cloud Models [18]

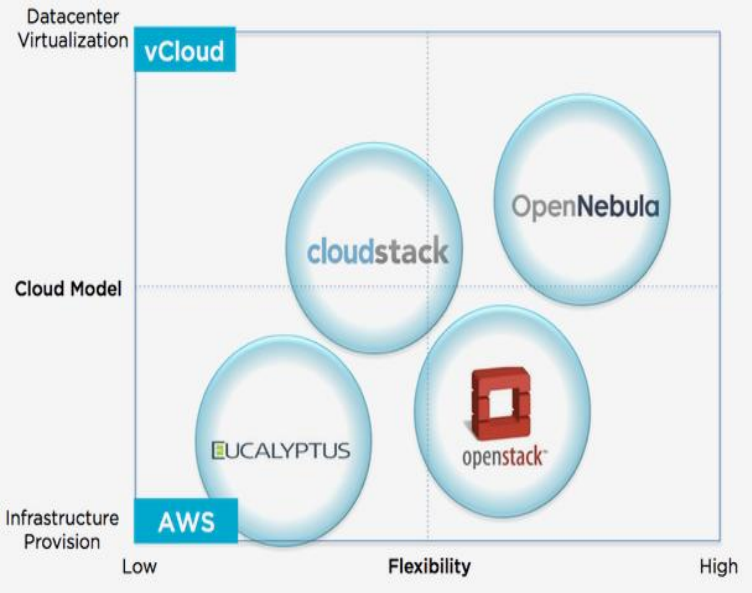

Figure 8 Datacenter Virtualization and infrastructure provision

Two Different Types of Models

1. Datacenter Virtualization
2. Infrastructure Provision

Figure clearly suggest that OpenNebula and Eucalyptus are in the different zones, servicing different needs and implementing completely different philosophies. OpenNebula with OpenStack because both represent flexible solutions that can be adapted to their needs, but wrongly think that both enable the same type of cloud. It is also clear that Eucalyptus and OpenStack meet the same need and so compete for the same type of cloud

TABLE 3 DIFFERENT PHILOSOPHIES BEHIND DATACENTER VIRTUALIZATION AND INFRASTUCTURE PROVISION

	Datacenter Virtualization	**Infrastructure Provision**
Applications	Multi-tiered applications defined in a traditional, "enterprise" way	"Re-architected" applications to fit into the cloud paradigm
Interfaces	Feature-rich API and administration portal	Simple cloud APIs and self-service portal
Management Capabilities	Complete life-cycle management of virtual and physical resources	Simplified life-cycle management of virtual resources with abstraction of underlying infrastructure
Cloud Deployment	Mostly private	Mostly public
Internal Design	Bottom-up design dictated by the management of datacenter complexity	Top-down design dictated by the efficient implementation of cloud interfaces
Enterprise	High availability, fault tolerance, replication,	Most of them built into the application, as in

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Capabilities	scheduling… provided by the cloud management platform	"design for failure"
Datacenter Integration	Easy to adapt to fit into any existing infrastructure environment to leverage IT investments	Built on new, homogeneous commodity infrastructure

TABLE 4 CHARACTERISTICS OF OPENNEBULA, EUCALYPTUS, OPENSTACK, CLOUDSTACK

	OpenNebula	**Eucalyptus**	**OpenStack**	**CloudStack**
Service Type	IaaS	IaaS	IaaS	IaaS
Scalability	Scalable	Scalable	Scalable	Scalable
Interface	OCCI, EC2 Query, EBS, simple Sun-Stone cloud user view, UNIX-like CLI, and Powerful Sunstone GUI, Ruby, Java, XML-RPC API	EC2, S3, EBS, Rest Interface	EC2, S3, RestFul Api Interface	easy to use Web interface, command line tools, RESTful API. API compatible with AWS EC2 and S3
Hypervisor	Xen, KVM,VM Ware	VMWare (ESX/ESXi), KVM, Xen	KVM, Xen, LXC, UML, VMWare	VMware, KVM, XenServer and Xen Cloud Platform (XCP)
Networking	1. Service Network 2. Instance Network - dummy, fw, 802.1Q, estables, ovswitch, VMWare	Elastic IP, security groups, DHCP Server, and layer 2 VM isolation Four Modes : 1. Managed, 2. Managed-novLAN, 3. Static, in (1)and (2) bridges are created automatically	- Two Modes 1. Flat Networking 2. VLan Networking	VLan Networking, VMWare, Firewall, Reserved System IP Addresses
Software Deployment	Installed in frontend	- Software is composed by component that can be placed in different machines. - Compute nodes need to install OpenStack software	- Software is composed by component that can be placed in different machines. - Compute nodes need to install OpenStack software	- Software is composed by component that can be placed in different machines. - Compute nodes need to install CloudStack software
DevOps Deployment	Chef, Puppet	Chef, Puppet	Chef, Puppet, Crowbar	Puppet
Storage (Image Transference)	- System, Image and file Data store - SAN/NAS Server, vmfs, LVM, Ceph	Walrus (http/s)	Swift(http/s), Unix File System(ssh)	VHD, OVA, QCOW2
Authentication	User/Password, SSH, X 509, LDAP	LDAP, CHAP	X 509, LDAP	LDAP and User Authentication, SSH
Avg. Release Frequency	> 6 Month	> 4 Months	< 4 Months	> 4 Months
License	Open-Source Apache	Open-Source + Commercial	Open-Source Apache	Open-Source Apache

V. CONCLUSION

While analyzing different open source cloud management platforms, we observe that there are different philosophy involve while designing the Cloud Management Platforms. OpenNebula and CloudStack is more towards the Datacenter Virtualization and Eucalyptus and OpenStack is more towards the infrastructure provisioning. Among all four CMP's OpenNebula is more flexible compare to all other platforms. Also it is possible to do so much of customization and ongoing development makes it accurate behind the statement.

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