

Comparative Study of OpenNebula, CloudStack, Eucalyptus and OpenStack

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Abstract: Over the last few years, many open source Cloud Management Platforms (CMPs) have come into existence. Developers, Cloud Providers and Consumers need to resolute to a cloud platform which best suits their needs. OpenNebula, CloudStack, Eucalyptus and OpenStack are among the major players that commercially provide a cloud management platform. Having several options to choose from, it can become difficult for new businesses to select a platform which caters to all their needs. However, the market has room for several open source cloud platforms that perform different tasks and finally fit together into an extensive cloud ecosystem. Some existing literatures only compare the basic features of these platforms. The main goal of this paper is to provide a practical reference to help businesses understand the features being provided by the above-mentioned Cloud Management Platforms and assist them in making a selection of a CMP that best suits their requirements. All of these platforms provide Infrastructure as a Service.

Keywords: Cloud Management Platform (CMP), CloudStack, Eucalyptus, OpenNebula, OpenStack.

I. INTRODUCTION

Cloud Computing provides on demand sharing of computing resources over the internet instead of using local servers to manage software programs. [1]

Cloud computing provides three types of services:

- (a) Software as a Service (SaaS)
- (b) Platform as a Service (PaaS)
- (c) Infrastructure as a Service (IaaS)

Software as a service comprises of web applications which work on remotely located systems that are maintained by other

organizations and connect to users' systems through the internet. SaaS enables users to sign up and instantly start using business applications. The data and applications are readily accessible from any connected computer. If a computer malfunctions, there is no loss of data as the data is preserved in the cloud. With the help of SaaS, users are saved from buying, installing, and maintaining their software.

Platform as a service makes available a cloud-based environment providing users with all the resources to build and deploy cloud applications without the complications of purchasing and maintaining their hardware and software as well as hosting services. PaaS enables developers to develop applications and market them in a fast and easy way. Web applications can be distributed to both private and public cloud with ease.

Infrastructure as a service provides organizations with computing resources such as storage devices, servers, networking and data centers on pay for use basis. IaaS enables companies to provide flexible and on demand services. Companies also benefit as there is no need for them to invest in their own hardware. [2]

This paper primarily focuses on IaaS cloud platform.

A. Open Source Cloud Management Platforms

i. OpenNebula

OpenNebula provides simple but effective and customizable solutions for extensive management of virtualized data centers to permit public, private and hybrid IaaS clouds. OpenNebula provides flexible architecture, networks and modules which are easy to integrate into any data center. It also supports Xen, VMware, KVM and can make use of Amazon EC2s. OpenNebula consists of the following components: Front-end, Hosts, Datastores and Physical Networks as shown in Fig. 1.

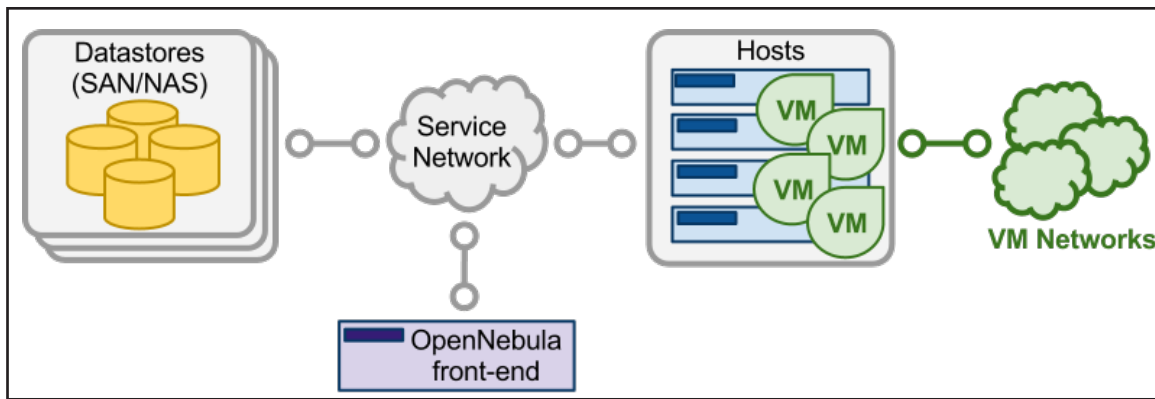


Fig. 1: OpenNebula Architecture [12]

OpenNebula was devised to be a platform that could integrate into any storage and network solution. It maintains networking, storage and virtualization technologies to allow the initiation of on-demand services on distributed infrastructures and merging the resources of physical equipment and cloud. The goal of OpenNebula is to combine existing virtualization technologies with advanced features in multi-tenancy, automatic provision and elasticity, following a bottom-up approach driven by the real needs of System Administrators. OpenNebula is an open source software under the Apache license. [3, 4]

ii. CloudStack

Apache CloudStack is an open source project devised to set up and administer a wide network of virtual machines. It aims to be a highly accessible and customizable Infrastructure as a Service (IaaS) platform. The software is used by a variety of service providers to give users public cloud facilities, and by many organizations to provide a private cloud environment. It is also implemented by companies as a part of a hybrid cloud option. CloudStack tries to provide an entire set of features that most organizations desire from an IaaS platform i.e. user and account management, native APIs, accounting of resources and a top-notch User Interface to name a few. CloudStack supports a wide variety of hypervisors including Citrix XenServer, KVM, VMware, Xen Cloud Platform (XCP), Microsoft Hyper-V and Oracle VM server. Additionally, CloudStack offers users an API that is compatible with AWS EC2 and S3, for those who wish to distribute hybrid clouds.[5]

iii. Eucalyptus

Eucalyptus is an open source platform for creating Amazon Web Service (AWS) API compatible hybrid and private clouds. It can be scaled up or down on demand depending on workload of the application making for a well-suited solution for business clouds. With Eucalyptus, companies can bring a public cloud experience through private IT services to attain improved finances, better data governance and faster application performance. Eucalyptus enables organizations to

establish AWS applications in a private cloud without changing tools, processes, or application code as it provides open source implementations of many Amazon Web Services. Eucalyptus has several components as shown in Figure-II below such as Cluster Controller (CC), Cloud Controller (CLC), Node Controller (NC), Walrus Storage Controller (WS3), and Storage Controller (SC). [7]

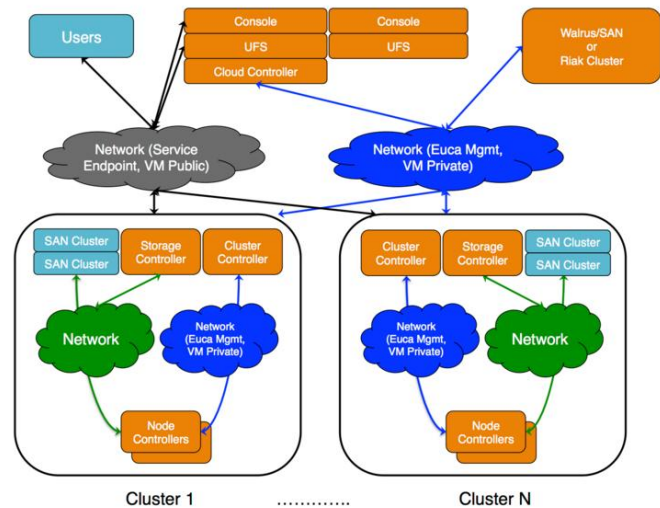


Fig. 2: Eucalyptus Architecture [7]

iv. OpenStack

OpenStack is an open source cloud management platform that maintains large amounts of storage, compute, and networking services through a data center which is operated via a dashboard. The dashboard enables users to provision resources through a web interface and also provides administrator controls [8]. It is a worldwide collaboration of developers to provide a cloud operating system for both private and public clouds. Organizations can fully take advantage of the available licensed software to build their own cloud environments. The OpenStack architecture consists of several components such as a Client, REST API, Database Abstraction Layer (DAL), Glance Domain Controller, Glance Store and a Registry Layer as shown in Fig. 3.

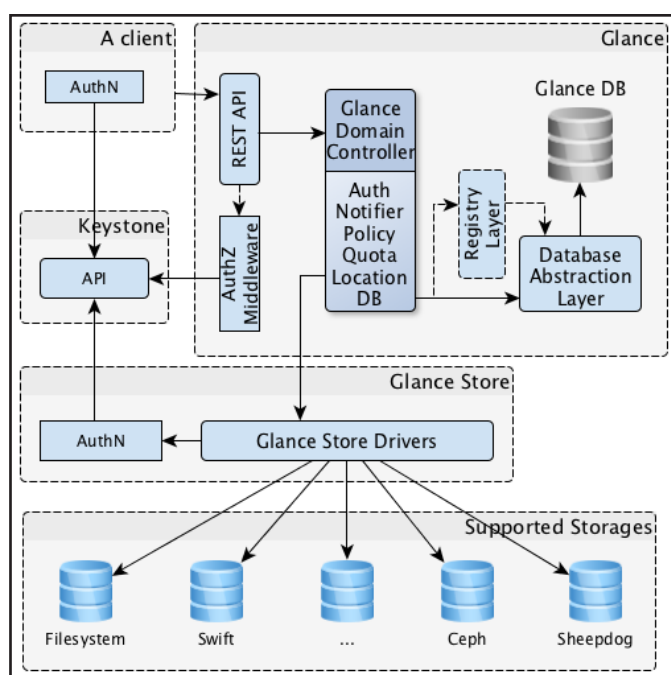


Fig. 3: OpenStack Glance Architecture [9]

II. METHODOLOGY

Cloud computing has a great potential for today's computing needs and could be understood via various ways but it is mostly categorized under the following two models:

- *Datacenter Virtualization:* There are some corporations that think of cloud as a comprehension of datacenter virtualization, and hence look for an automated tool like v Cloud that coordinates and simplifies the maintenance of virtualized resources.
- *Infrastructure Provision:* Other corporations think of it as an AWS-like cloud, and therefore look for a resource allocation tool that provides virtualized resources as needed.

Most users using the first cloud model alternative might openly make an effort to find a substitute to v Cloud as it can turn out to be quite expensive, or they do not want to be locked to a vendor or because it might not be able to adapt to their requirements. Users who find themselves in the second cloud model might openly point out Amazon as the form of cloud that they want to create internally. [10]

The following table outlines the main characteristics of both cloud models:

TABLE I: COMPARISON OF DATACENTER VIRTUALIZATION AND INFRASTRUCTURE PROVISION

	<i>Datacenter Virtualization</i>	<i>Infrastructure Provision</i>
Applications	Multitier software programs established in the conventional, "enterprise" way	Re-architected software programs that are compatible in the cloud criterion
Interfaces	Feature rich APIs and an administration portal	Simple cloud APIs and self-service portal
Management Capabilities	Comprehensive maintenance of virtual and physical resources	Easy maintenance of virtual resources while hiding the basic infrastructure
Cloud Distribution	Mostly private	Mostly public
Internal Design	Bottom up design determined by the maintenance of datacenter complexity	Top down design determined by the efficient execution of cloud interfaces
Enterprise Capabilities	High accessibility, defect tolerance, duplication and scheduling provided by the cloud management platform	Mostly found built into the applications
Datacenter Integration	Easy to model into any existing infrastructure environment to influence IT investments	Built on new, homogeneous commodity infrastructure

The following diagram helps us understand better the current and future status of the cloud market. Vertical axis represents the "cloud model" and horizontal axis represents the "flexibility" in terms of a product's potential to tailor to datacenter services and

its ability to be customized in order to provide a differentiated cloud service. The four major open source players that provide cloud services are OpenStack, CloudStack, OpenNebula and Eucalyptus.

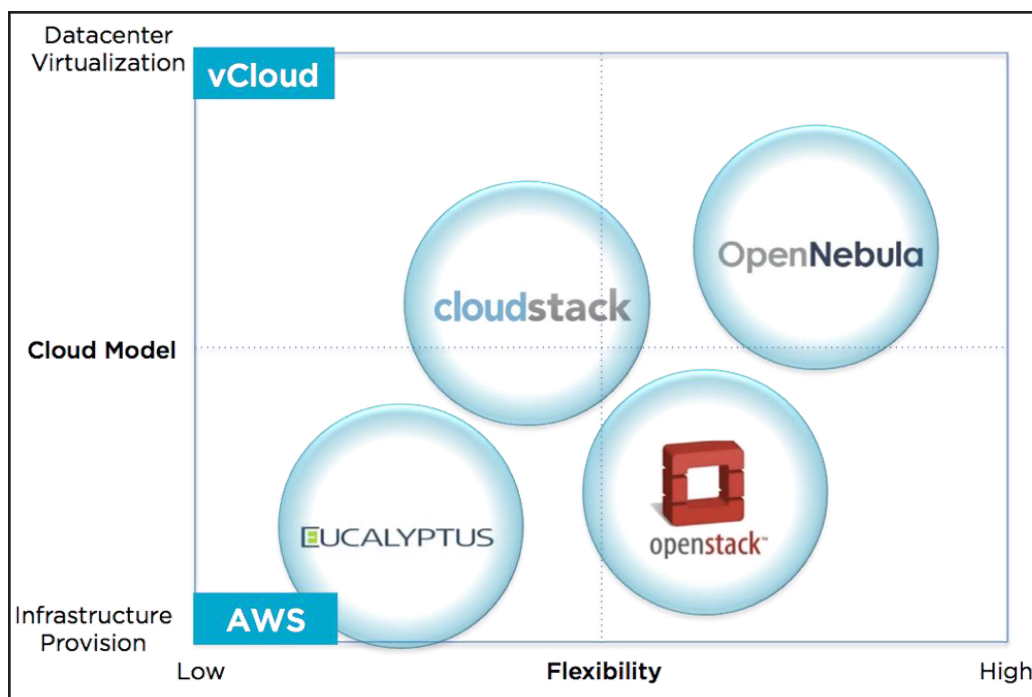


Fig. 4: Datacenter Virtualization and Infrastructure Provision [10]

OpenNebula and Eucalyptus differ in their philosophies and their target audiences. They get placed in opposite sections of the quadrant as they cater to different needs and implement their own respective philosophies. Many organizations often compare OpenStack with OpenNebula as they both provide versatile solutions and can be customized as per the requirement. However, it is mistakenly believed that they are the same type of cloud. It is also apparent that OpenStack and Eucalyptus rival each other in the same type of cloud as they cater to the same requirements. [6, 10]

Comparison of OpenStack, CloudStack, Eucalyptus, OpenNebula

All four Cloud Management Platforms being discussed are completely open source when considering their source codes. OpenStack, CloudStack and OpenNebula are licensed under Apache v2.0 whereas Eucalyptus is licensed under GPL v3.0 only with proprietary relicensing.

TABLE II: CLOUD MANAGEMENT PLATFORM SOURCE CODES

	<i>Openstack</i>	<i>Cloudstack</i>	<i>Eucalyptus</i>	<i>Opennebula</i>
Source Code	Completely open source using Apache v2.0	Completely open source using Apache v2.0	Completely open source using GPL v3.0	Completely open source using Apache v2.0

(a) Developer Perspective

The following factors can be used as a way of comparison through the perspective of a corporation.

- Development Model: Helps in stating what the public wants.

- Developer Engagement: Helps in stating the amount of external aid in the development process.
- Governance Model: Helps in stating how roadmap decisions are made.

TABLE III: PERSPECTIVE OF THE DEVELOPER

	<i>Openstack</i>	<i>Cloudstack</i>	<i>Eucalyptus</i>	<i>Opennebula</i>
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

The above mentioned four open source cloud management platforms get licensed under similar agreements and are developed over the public internet. There is however a small deviation in their governance models. While CloudStack follows the Apache meritocracy rules, OpenStack believes in following a foundational approach under the strategic supervision of their Board of Directors. OpenNebula and Eucalyptus are maintained by the same organization which believes to keep the project as their prime target of attention and direct them strategically to ensure that they satisfy the requirements of the community and its users. Benevolent dictator governance is the model that seems to have found success and has been pursued by other thriving projects like Android and the Linux Kernel. It might be the most efficient approach to keep track on the engineering quality and to be active and approachable to the users so as to ensure long term support. [2, 11]

(b) User Perspective

In this scenario, viewpoints of both the consumer (user of the cloud) and the builder (user of technology) should be considered.

- From the view of the cloud consumer, “open cloud” is mostly about data formats and APIs. Common

API’s provide us with the freedom to run anywhere, irrespective of their ability to be supported in an open source manner. This gives the user an ability to evaluate different cloud offerings, select from various options that best suit his requirements, and even switch providers if he is not satisfied with the service or if he finds a more reliable option.

- From the view of the cloud builder, “open cloud” means that the hub or the community of the open source software is enterprise status and supported by large number of systems commercially without having the need to install a vendor improved distribution. This is exactly where users and technology buyers can assess the openness of the project.

From the viewpoint of the user, the following points could be selected:

- API Ecosystem: States whether the software is supporting an effective standard with a wide ecosystem
- Production Readiness: Helps selecting the right market according to the supported use.

TABLE IV: PERSPECTIVE OF THE USER

	<i>Openstack</i>	<i>Cloudstack</i>	<i>Eucalyptus</i>	<i>Opennebula</i>
API Ecosystem	OpenStack API	Amazon API	Amazon API	Amazon API
Product Readiness	No. It is only accessible via any of the various vendor specific stacks	Business ready and benefits with constant support from developers	Business ready and benefits with constant support from developers	Business ready and benefits with constant support from developers

A corporation needs its cloud management platform to be enterprise ready, stable with long term commercial support, and a beneficial upgrade procedure. It can be seen that Open Nebula and Eucalyptus are comparatively more open and either of them can offer users a cloud platform ready for business. Any organization can take advantage of the available open source distribution to create a cloud that caters to their needs and can benefit from constant and lucrative support directly from developers. A noteworthy aspect is that these projects usually do not supply business versions of their software but they do provide commercial support for their public software. This group also includes CloudStack as the Citrix Cloud Platform is a business distribution which fails to deliver comprehensive features. On the other hand, any organization that wants to try OpenStack, and requires commercial support is usually suggested to install any of the various offerings being issued by the vendors imparting to the project. These distributions integrate different versions of OpenStack modules providing enhanced features, routine improvements and implementations which may make it harder to be compatible. So, the company is now using OpenStack based software and is now bound to that particular distribution. This scenario occurs when the vendor

only provides support for his own stack and there are no means to switch to another vendor distribution. [6, 11]

III. RESULTS AND DISCUSSION

The selected platforms chosen for comparison in this paper were OpenNebula, CloudStack, Eucalyptus and OpenStack. OpenNebula is simple, efficient and customizable. It provides an architecture which can be moulded as per the requirements and hence can be easily integrated with any datacenter. CloudStack can cater to a large network of virtual machines and also tends to provide the most common set of features that organizations desire from an IaaS platform. Eucalyptus commands can manage a wide variety of Amazon Web Services. It also has the ability to scale up or down depending on the application which makes it suitable for enterprise clouds. OpenStack is ideal for fulfilling administrative requirements. OpenStack also benefits from a solid base of developers and community members at a global level which makes it a top cloud operating system. Eucalyptus and OpenNebula have different philosophies and hence cater to different target audiences. OpenStack and

OpenNebula have a somewhat similar approach as they both provide versatile solutions and can be easily customized. All four Cloud Management Platforms get licensed under similar agreements however some deviations can be observed in their governance models as each platform follows its own ideology.

IV. CONCLUSION

Cloud computing is one of the most trending research topics and this technology has been extensively studied in recent years. Many organizations have caught upto implement cloud computing practices and various cloud management platforms have come into existence. Understanding and using these platforms can be daunting. This paper attempts to provide a detailed comparison of these platforms. Though each CMP has its own strengths, one cloud platform cannot dominate over the other. Different philosophies were used while designing each CMP. CloudStack and OpenNebula direct more towards datacenter virtualization while OpenStack and Eucalyptus lean more towards infrastructure provisioning. Different organizations use different Cloud Management Platforms and each requires a different architecture. A single CMP will therefore struggle to fulfill all requirements of all people and hence various offerings have been introduced in the cloud computing industry giving organizations choice as to which platform best suits their needs.

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