Does Selection of Open Source Cloud Computing Platforms is a Confusing Task?

Hafiz Ahmed Ali, Khisaluddin Shaikh, Murk Chohan, Kainat Fareed Memon, Muhammad Saleem, Adil Khan

Abstract*: Over the last few years the majority of small and large companies moving to cloud computing to develop IT solutions for businesses. It is technology which provides distributed and dynamically shared computing resources using certain operating techniques. In the revolution of information technology, cloud computing is becoming a key paradigm. Cloud computing further classified as Public, Private and Hybrid Cloud. It provides three services which are categorized as Infrastructure-as-Service, Platform-as-Service and Software-as-Service. Open source cloud management platforms providing Infrastructure-as-a-service are now commonly used because of the fastest growth of cloud. Many open source softwares are available for deploying public or private cloud. This paper provides a brief review and comparison of five well-known open source cloud software i.e. OpenNebula, Eucalyptus, OpenStack, Nimbus and CloudStack providing IaaS on the basis of their similar features and technology used. After reviewing the importance and features, we have found OpenStack Cloud Platform is more reliable and useful for the enterprises and organization because of its feature and rapid improvements in its features. The distinction in this paper is believed to help people to choose the suitable open source software according to their need.

Keywords: IaaS, Open Source Cloud, Cloud Computing, Nimbus, OpenNebula, OpenStack, Eucalyptus, CloudStack.

I. INTRODUCTION

Nowadays, it is very easy to access different content through internet. Several platforms are there to provide services in this regards [1]. In the revolution of information technology, cloud computing is becoming a key paradigm [2]. Cloud computing is an architecture to provide services related with IT enable technologies instead of products. It also provides a great flexibility regarding domain of the application. Cloud computing is another paradigm that provides consumers with easy on-demand services. The computing resources are distributed and dynamically shared using certain operating techniques which mostly contain multi-continent isolation layers [3]. Cloud Computing is a combination of many technologies that are formerly exist i.e. Grid and Distributed computing, virtualization that led the Cloud computing as a fruitful technology. CLOUD is abbreviated as "Computing Location independent Online Utility" that is available on-Demand [4]. The key components of cloud computing are Resource sharing, abstraction, virtually scalability and dynamic. With the help of these components utilization of resources and payment is as per utilization and due to a limited utilization obviously cost will decree because of no maintenance. Scalability can also be achieve in this efficient resource utilization of any of the components by availing the services if more services are required it can be scale up easily or even in a few seconds without any deployment of the whole system at a specific place. There are services that cloud computing provides: Software-as-Service, Infrastructure-as-Service and Platform-as-Service [5].

Cloud service providers propose one of the commonly used service related with cloud computing named as Infrastructure as a service (IaaS). Where a number of virtualization machines are provided for instance CPU, storage for data, and network compatibility for the customers [6]. They provide a reliable control on the Virtual Machines (VMs) to facilitate them without manipulation in their bare mettle level of hardware. Some working example of IaaS are (GCE) Google Compute Engine in Google Cloud Platform and Amazon EC2 [7]. Furthermore, another service which is provided by cloud services providers is (PaaS) Platform-as-Service use to develop and implementation of user defined applications. The major services through which PasS can be achieved are different development environments, programming languages and libraries, application based server technology. Compatibility with the different web services and databases are also a feature of a PaaS. Platofrm-as-Service also proposed the facility of auto Testing and auto Development for programmers. Some PaaS vendors are Caspio, Google App Engine and Red Opens Shift [8].

Third major service of cloud computing is Software-as-Service (SaaS). This is somehow like Platform-as-Service but in PaaS is to develop and deploy the application as per the user but here in SaaS applications are provide on the basis of demand used that are hosted and manage by the cloud service providers. SaaS also led to low cost due to not having maintenance that is done by the service providers. Some examples are Google Docs, Zoho etc [9].

Revised Manuscript Received on April 21, 2020.
***** Correspondence Author
Hafiz Ahmed Ali *, Department of Computer Science, Sukkur IBA University, Sukkur, Pakistan, Email: hafiz.mcs18@iba-suk.edu.pk
Khisaluddin Shaikh, Department of Computer Science, Sukkur IBA University, Sukkur, Pakistan, Email: khisal.msse17@iba-suk.edu.pk
Murk Chohan, Department of Computer Science, Sukkur IBA University, Pakistan, Email: murk.mcs18@iba-suk.edu.pk
Kainat Fareed Memon, Department of Computer Science, Sukkur IBA University, Sukkur, Pakistan, Email: kainat.mscss19@iba-suk.edu.pk
Muhammad Saleem, Department of Computer Science, Sukkur IBA University, Sukkur, Pakistan, Email: msaleem.jcd@iba-suk.edu.pk
Adil Khan, Department of Computer Science, Sukkur IBA University, Sukkur, Pakistan, Email: adil.mcs18@iba-suk.edu.pk

In this study we aim to discuss the open source cloud platforms and investigate their difference which may help the developers in selecting the best cloud platform for their projects. Such systems have the general purpose of providing virtual machines for a cloud that offers an infrastructure as a service network [10]. Different open-source softwares (i.e. OpenNebula, Eucalyptus, OpenStack, Nimbus and CloudStack) are there providing significant alternatives to people who do not want to use the cloud services offered commercially.

II. OPEN SOURCE CLOUD SOFTWARES

To align and facilitate the users in this modern era, various cloud platforms are available openly. However, we have selected and explained the five open source cloud softwares based on easy to use and availability.

A. OpenNebula

OpenNebula first available for public in 2008. This is a project of Ruben S. and Liorente M developed in 2005. This aim of this project is to manage the virtualization of data centers provide paid service as private cloud. OpenNebula Cloud infrastructures provide a fast delivery and scalability framework for users to encounter diverse service demands of customers. Each service is accommodated by virtual machines, also submitted, monitored and controlled in the cloud through virtual interfaces, like the CLI, XML-RPC API, Libvirt virtualization API etc. [11]. The user receives a configuration file that includes parameters to be entered on the VMM command line to create a VM. OpenNebula's configuration through customization impacts users and administrators. The default configuration of OpenNebula with NFS file system showing that the centralization of OpenNebula. The centralization feature of OpenNebula makes it more powerful and easier to use system for the administrator. OpenNebula is now become the open source software which is providing the virtual machine management functionality and also management of private cloud computing framework [12]. OpenNebula is used by telecom operators to virtualize the kind of web servers, mailing systems and databases. It supports Public Cloud with Web APIs to illustrate their virtual machine, storage and network management capabilities.

B. Eucalyptus

Eucalyptus has been developed as a commercial EC2 cloud open-source solution. Eucalyptus has been conceived to handle and control large distributed resources collections. This is developed to provide the infrastructure-as-service functionalities to the customers for virtualization of their resources and become one of the most favorite and efficient open source cloud softwares compatible with Amazon Web service API in 2008 for deployment of private cloud for the organizations. Amazon (AWS) is one of the prominent infrastructure-as-service provider. The Amazon Web API offers two major services such as Elastic Compute Cloud (EC2) and Simple Storage Service (S3). Yadav [4] explained the term EUCALYPTUS as “Computing architectural elastic utility to link your software to a functional device”. Its customers uses the very same software and frameworks to communicate which they uses with the Amazon EC2 framework for interaction [13]. The S3-compatible cloud Storage and EC2-compatible Cloud both infrastructure are provided by Eucalyptus, and therefore the services are accessible via EC2/S3 based APIs [14]. It has four high level components, every component have its own interface for web service. 1) Storage Controller: A data storage infrastructure using standard Web-Services (Axis2, Mule) and an Amazon-based Simple Storage Infrastructure (S3) interface System [15]. It provides storage and access mechanism for images and user data on a virtual machine. It also offers network block level storage with support for Elastic Block Storage (EBS). 2) Cloud Controller: This facilitates the management of virtualized resources. This is a user and administrator entry point in the cloud. Cloud Controller is a set of web services best divided into three groups by their functions i.e. Resource Services, Interface Services and Data Service [13]. It needs node managers to provide resources details, takes high level planning decisions and then implements them by demanding cluster controller. 3) Cluster Controller: It is executed on a networked system with the computers running Node Controller and Cloud Controller. Each Node Controller for a single CC must be in one subnet. CC consists of three main properties: to prepare incoming instance requests to certain NC, to handle virtual system instance overlays and to collect / report NCs. 4) Node Controller: An NC queries the system at its node and monitors it in answer to requests from its Cluster Controller. It also monitors VM instances execution, inspection, and termination on the server it is running.

C. OpenStack

OpenStack is a NASA-built framework for large infrastructure. This project is funded by many companies around the world (in particular the US) and is focused on NASA and Rackspace Cloud technology. In order to power OpenStack Object Storage, Rackspace contributed its "Cloud Files" framework. The NASA contributed its "Nebula" platform to power the compute component [16]. It is open, scalable and flexible system that is compatible with existing systems. Because of its nature and culture and the encouragement of its partners, it possesses great potential. All code is approved by the license of Apache 2 [17]. Due to its characteristics can become the reference solution in open source cloud computing. The services are offered through compatible APIs for Amazon S3/EC2 and so AWS client tools can be used with OpenStack too [4]. It is a series of Open Source software projects that can be used by businesses or cloud providers to set up their cloud device and storage infrastructure. In order to ensure high availability of users ' applications additional modules provide, among other features, orchestration, fault management and service management beyond the traditional infrastructure as a service functionality. There are mainly three core projects of OpenStack i.e. Nova, Glance and Swift. Nova is the compute node which is the major part of the OpenStack [18]. All life cycles in the cloud are supported by Nova.

The framework includes six components: Nova-API, Nova-Computing, Message Tail, Nova-Volume, Nova-Scheduler and Nova Networking. Swift is the long-term storage system to collect, leverage and update permanent types of statistical information [18]. Highly sheltered storage of large and sized items, data replication, archival capability and media streaming is the key functions and features. Glance The OpenStack image solution for creating a virtual machine image lookup and retrieval system known as Glance. The Glance register and glance control are the two parts of the glance and provide only an imaging service feature. Apart from the above mentioned projects, the OpenStack has now several projects (i.e. Keystone, Horizon, Neutron, Cinder, Blazar and Heat) form the supporting organizations.

D. Nimbus

The Nimbus project specifically claims to be a software system for "sciences." [19] [20] [21]. The goal is to allow users to fast and easily migrate to the cloud, to simplify and encourage much of the process. Also aims at creating a bridge that allows users to overlay common concepts such as virtual clusters on cloud resources. Nimbus also has a Globus project partnership and uses Globus app authentication credentials. Nimbus is customizability feature like OpenNebula. Nimbus allows the administrator rather than the user to personalize most of the time and has several other constant components i.e. Cumulus, The use of Globus authentication for any user authentication and the need for cleanly SSH in all calculation nodes for the running Nimbus phase. Nimbus is probably the largest focus on space allocation and the overload of capacity. Nimbus is standard for the ability of different users to set different lease limits as a schedule. Nimbus also offers an Amazon's Elastic Compute Cloud (EC2) application that allows you to use Nimbus-based cloud clients built for the true EC2 network [19] [22]. It enables customers to build automated clusters. Multiple VMs may be created and launched at one time also can be stored all the VMs without any private credentials

E. CloudStack

CloudStack, developed by Cloud.com and subsequently sponsored by Citrix. Later on Citrix contributed the Apache Software Foundation with CloudStack [23]. It is an open source cloud computing platform to deploy and maintain as a highly available, highly scalable Servicing Infrastructure (IaaS) wide virtual machines networks [24] CloudStack offers an API for companies that want to implement hybrid clouds that is compliant with AWS EC2 and S3 [25]. The VMware, CVM, Citrix Xen Server, Xen Cloud Platform (XCP), Windows Hyper-V and Oracle VM Server are all supported on the CloudStack. CloudStack offers high efficiency for efficient multi-locator cloud computing. A predefined template will create virtual servers with one-click. Virtualizations can be interrupted, paused and restarted via the Web interface, command line or the CloudStack API. It also increases efficiency in the allocation of resources and corporate use of services.

III. RESULT AND COMPARISON

This section of the study compares five open source cloud softwares (i.e. OpenNebula, Eucalyptus, OpenStack, Nimbus and CloudStack) based on evaluation criteria from various cloud features such as structure/architecture, main purpose, hypervisors, supported cloud types, supported platform, cloud service model, networking, scalability and programming languages etc. All of the discussed platforms are providing Infrastructure as a Service for the distribution of virtualized environment to the user as a service on their computers. All features compared in table 1 and also discussed below in detail. During our analysis and comparison, we have on the point that OpenStack cloud solution is one of the best cloud computing platform among all other platforms. The reason of comparing different features is to take the attentions of cloud computing customer to relate each open source platform and make decision of selection based on their business requirements.

A. Architecture

Eucalyptus and CloudStack has resemblance in their architecture as they have Hierarchical architecture in comparison with Nimbus and OpenNebula working on Centralized structure. While OpenStack is distributed in nature. CloudStack consists of five components: Pods, Clusters, Primary Storage, Secondary Storage and Availability Zone. Eucalyptus is made up by: Cluster Controller, Node Controller, Cloud Controller and (Walrus) Storage Controller. Nimbus and OpenNebula has cluster like architecture: node and master [6]. Whereas, OpenStack has several projects now included in its repository but the core projects that provide backbone to OpenStack are: Nova (Compute), Swift (Object Storage) and Glance (Image).

B. Hypervisor

Hypervisor is a physical hardware platform abstraction of software which allows multiple guests to run on one physical machine simultaneously. The Eucalyptus is available for enterprises and it is Xen, VMWare and KVM-compatible. Nimbus is compatible with XEN and KVM, available for Scientific Communities. OpenStack has compatibility with several hypervisors: LXC, QEMU, V sphere, HyperV, VMWare, XEN, KVM, UML Virtual Box and MS Hyper v. OpenStack is available for Researchers, Enterprises and Developers. OpenNebula that is specifically designed for researchers is compatible with KVM, VMWare and XEN hypervisor. While CloudStack is compatible with VMware, KVM, Citrix Xen Server, and Citrix Xen Cloud Platform.

C. Cloud Implementation

Nimbus is only supports the deployment of public cloud. However, OpenStack and OpenNebula are best for deploying public, private and hybrid cloud platforms as they both are supported all cloud types. While Eucalyptus is useful for private and hybrid cloud types.

D. Programming Language

OpenStack components are written in Python. OpenNebula used few other languages such as Java, Ruby, C and C++. CloudStack is written through the java.

Eucalyptus and Nimbus both supported with Java and Python. While some components (Cluster Controller and Node Controller) of Eucalyptus are written in C Language.

E. Compatible APIs

Eucalyptus, OpenStack and Nimbus are compatible with AWS EC2 and S3 API. OpenStack also support EBS and OCCI. OpenNebula compatible with AWS EC2, S3, Native XML/RPC and OCCI. CloudStack supports Amazon EC2 and S3 APIs.

Table- I: Open Source Cloud Platform Comparison Table [6]

CLOUD PLATFORM	FEATURE								
	ARCHITECTURE	HYPERVISOR	IMPLEMENTATION	PROGRAMMING LANGUAGE	API'S	LATEST VERSION	NETWORKING	LICENSE	VM MIGRATION
OPENNEBULA	Centralized structure	KVM, VMWare and XEN	Public, Private and Hybrid cloud	Java, Ruby, C and C++.	AWS EC2, S3, Native XML/RPC and OCCI	5.10.1	VLAN	Apache 2.0	Yes
EUCALYPTUS	Hierarchical	Xen, VMWare and KVM	Private and Hybrid cloud	Java, Python and C.	AWS EC2 and S3 API	4.4.3	novLAN systems, IP is static and managed	GPL	No
OPENSTACK	Distributed	LXC, QEMU, V sphere, HyperV, VMWare, XEN, KVM, UML Virtual Box and MS Hyper v	Public, Private and Hybrid cloud	Python	AWS, EC2, S3 API, EBS and OCCI	Train	Flat DHCP, VLAN DHCP	Apache 2.0	Yes
NIMBUS	Centralized structure	XEN and KVM	Public cloud	Java and Python	AWS EC2 and S3 API	2.8	DHCP server	Apache 2.0	No
CLOUDSTACK	Hierarchical	VMware, KVM, Citrix Xen Server, and Citrix Xen Cloud Platform.	Public cloud	Java, Python	Amazon EC2 and S3 APIs	4.13.0 .0	VLAN	Apache 2.0	Yes

F. Latest Version

Eucalyptus 4.4.3, OpenNebula 5.10.1, OpenStack Train, Nimbus 2.8 and CloudStack 4.13.0.0.

G. Networking

In OpenNebula and CloudStack, networking is managed through VLAN. Eucalyptus is followed managed novLAN systems, IP is static and managed. However, in Nimbus cloud platform IP can be configured in two different ways using a DHCP server. While in OpenStack IP is configured using Flat DHCP, VLAN DHCP. Neutron component of OpenStack is responsible for networking.

H. License

Apache License 2.0 is for all except Eucalyptus that has GPL.

I. VM Migration

Nimbus and Eucalyptus does not provide the migration of VMs. While OpenStack, OpenNebula and CloudStack support this feature.

IV. CONCLUSION

This paper provides a detailed comparative approach to these systems and discusses various implementation characteristics and features i.e. design, supported frameworks, networking, languages and hypervisors. Although there are many cloud services for industrial and academic applications, it is a big challenge for an organization and users to choose a most suitable platform based upon their needs. In this study we compare five most widely used open source cloud platforms i.e. OpenNebula, Eucalyptus, OpenStack, Nimbus and CloudStack (Shown in Table.1. We have found OpenStack Cloud Platform is more reliable and useful among all the other open source cloud softwares for the enterprises and organization because of its feature and rapid improvements in its features. The comparison performed on the basis of current Open Source softwares features, structures and technologies. The summary and assessment permit end users to select better cloud services on demand.

REFERENCES

1. Y. Uchida, S. Matsuno, M. Hasama, T. Ito, and M. Sakamoto, “A Study of Open Source Cloud System for Small and Medium Enterprise,” J. Robot. Netw. Artif. Life, vol. 1, no. 2, pp. 155–159, 2014.
2. K. Ren, C. Wang, and Q. Wang, “Security challenges for the public cloud,” IEEE Internet Comput., vol. 16, no. 1, pp. 69–73, 2012.
3. D. Bernstein, “Containers and cloud: From lxc to docker to kubernetes,” IEEE Cloud Comput., vol. 1, no. 3, pp. 81–84, 2014.
4. S. Yadav, “Comparative study on open source software for cloud computing platform: Eucalyptus, openstack and opennebula,” Int. J. Eng. Sci., vol. 3, no. 10, pp. 51–54, 2013.
5. M. A. Vouk, “Cloud computing�Issues, research and implementations,” in ITI 2008-30th International Conference on Information Technology Interfaces, 2008, pp. 31–40.
6. S. Shahzadi, M. Iqbal, Z. U. Qayyum, and T. Dagiuklas, “Infrastructure as a service (IaaS): A comparative performance analysis of open-source cloud platforms,” in 2017 IEEE 22nd International Workshop on Computer Aided Modeling and Design of Communication Links and Networks (CAMAD), 2017, pp. 1–6.
7. S. Niranjani, R. Jehadeesan, S. Vanishree, and P. Karthick, “A Prototype for Private Cloud Implementation using Open-source Platform,” Int. J. Emerg. Technol. Comput. Sci. Electron., vol. 13, no. 1, 2015.
8. B. H. Hemamalini, L. Suresh, and K. R. Radhika, “A survey on cloud computing,” Int. J. Math. Comput. Res., vol. 1, no. 11, pp. 303–305, 2013.
9. A. Marinos and G. Briscoe, “Community cloud computing,” in IEEE International Conference on Cloud Computing, 2009, pp. 472–484.
10. P. Sempolinski and D. Thain, “A comparison and critique of eucalyptus, opennebula and nimbus,” in 2010 IEEE Second International Conference on Cloud Computing Technology and Science, 2010, pp. 417–426.
11. “Private Cloud Computing with OpenNebula 1.4.”
12. D. Milojičić, I. M. Llorente, and R. S. Montero, “Opennebula: A cloud management tool,” IEEE Internet Comput., vol. 15, no. 2, pp. 11–14, 2011.
13. D. Nurmi et al., “The eucalyptus open-source cloud-computing system,” in Proceedings of the 2009 9th IEEE/ACM International Symposium on Cluster Computing and the Grid, 2009, pp. 124–131.
14. D. Johnson, K. Murari, M. Raju, R. B. Suseendran, and Y. Girikumar, “Eucalyptus beginner�s guide-uec edition,” Ubuntu Serv., 2010.
15. “CRM Software: Customer Relationship Management - Salesforce India.” [Online]. Available: https://www.salesforce.com/in/crm/. [Accessed: 27-Dec-2019].
16. “OpenStack Compute Starter Guide,” 2011.
17. O. Sefraoui, M. Aissaoui, and M. Eleuldj, “OpenStack: toward an open-source solution for cloud computing,” Int. J. Comput. Appl., vol. 55, no. 3, pp. 38–42, 2012.
18. “Build the future of Open Infrastructure.” [Online]. Available: https://www.openstack.org/. [Accessed: 27-Dec-2019].
19. “About Nimbus - Nimbus.” [Online]. Available: http://www.nimbusproject.org/about/. [Accessed: 27-Dec-2019].
20. C. Hoffa et al., “On the use of cloud computing for scientific workflows,” in 2008 IEEE fourth international conference on eScience, 2008, pp. 640–645.
21. K. Keahey, R. Figueiredo, J. Fortes, T. Freeman, and M. Tsugawa, “Science clouds: Early experiences in cloud computing for scientific applications,” Cloud Comput. Appl., vol. 2008, pp. 825–830, 2008.
22. P. Marshall, K. Keahey, and T. Freeman, “Elastic site: Using clouds to elastically extend site resources,” in Proceedings of the 2010 10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing, 2010, pp. 43–52.
23. A. Beloglazov, S. F. Piraghaj, M. Alrokayan, and R. Buyya, “Deploying OpenStack on CentOS using the KVM Hypervisor and GlusterFS distributed file system,” Univ. Melb., 2012.
24. J. P. Mullerikkal and Y. Sastri, “A comparative study of OpenStack and CloudStack,” in 2015 Fifth International Conference on Advances in Computing and Communications (ICACC), 2015, pp. 81–84.
25. “Apache CloudStack: Open Source Cloud Computing.” [Online]. Available: https://cloudstack.apache.org/. [Accessed: 27-Dec-2019].

AUTHORS PROFILE

Hafiz Ahmed Ali received his Bachelor degree in Computer Science from Shah Abdul Latif University Khairpur and MS Computer Science degree specialized in Data Knowledge Engineering in 2019 from Sukkur IBA University. He has been researching in multidisciplinary areas i.e. Software Engineering and Cloud Computing. Currently he is working at The Benazir Bhutto Shaheed University of Technology and Skill Development Khairpur Mirs.

Khisaluddin Shaikh BS Computer Science (Shah Abdul Latif University Khairpur). Scholar at Computer Science Department enrolled in MS Software Engineering (Sukkur IBA University). ICT Teacher at The City School,Indus Campus Sukkur.

Murk Chohan Completed her BE Computer System Engineering from Quaid e Awam University of Engineering & Technology Nawabshah and received her MS Computer Science degree specialized in Data Knowledge Engineering in 2019 from Sukkur IBA University. Currently she is a faculty member of Computer Science department at IBA-IET Khairpur. Pakistan.

Kainat Fareed Memon is a Scholar and Enrolled in MS Computer Science at Computer Science Department, Sukkur IBA University. She has done BS Computer Science from Shah Abdul Latif University Khairpur in 2016.

Muhammad Saleem BS Computer Science (University of Sindh Jamshoro) enrolled in MS Computer Science (Sukkur IBA University). Faculty Member of Computer Science Department at IBA Community College, Jacobabad, Pakistan with over 6 years of experience.

Adil Khan is a faculty member of Computer Science department at IBA Community College Ubaro, Pakistan. He completed his BS Computer Science in 2016 and MS Computer Science specialized in Data Knowledge Engineering from Sukkur IBA University in 2019.