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A Comparative Analysis on Open Source Infrastructure as a Service Cloud Framework

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***Abstract*—** Cloud computing is one of the evergreen area where the resources such as data storage, infrastructure, and applications services are provided to the users over the network on demand. Cloud service providers charge users depending upon the space or service provided. So it is not always feasible to hire cloud services every time. Alternate to this, various cloud Infrastructure as a Service frameworks and simulation tools exist in recent years. It is difficult for end-users, developers and researchers to figure out which features and performance of each framework will match their problem statement. This paper analyses some of the most popular open source cloud computing software tools such as Eucalyptus, OpenStack, OpenNebula and CloudStack and also presented its feature comparison which facilitate the researchers and developers in selecting from the different open source cloud platforms.

***Keywords*—**Iaas, Eucalyptus, OpenStack, OpenNebula, CloudStack, Open source

I. INTRODUCTION

Cloud computing is nothing but the provisioning of virtualized no. of resources over the internet on demand [1]. The large and small businesses and IT industries have benefited with the services (web services, virtualization, service-oriented architecture, grid computing and utility computing) provided by the cloud computing. According to NIST, the cloud computing is "A model for enabling 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"[2]. The services delivered by the cloud are of three types namely SaaS (Software as a Service), Paas (Platform as a Service) and IaaS (Infrastructure as a Service) and it is deployed in the following ways: Public, Private, Community and Hybrid clouds. The commercial public clouds change the users by the hour and CPU time, and users are unaware of where their application will be processed and stored. Also, it provides limited control over the security of data. This paper focuses on Infrastructure as a Service (Iaas) model, which is the significant model where virtual machines, load balancers, block storage, firewalls and networking services are provisioning on site. This paper also analyses and compares the various feature set of most common open source cloud computing software tools such as Eucalyptus, OpenStack, Open Nebula and CloudStack for the deployment. Hence, Private cloud Infrastructure or any cloud simulation software will be a better alternative to companies, developers, and researchers for testing their cloud computing solution that best suits their needs. This paper helps the researchers and developers to quickly select the cloud frameworks by analyzing the defined feature set.

The rest of the paper is organized as follows: Section II briefly describes the virtualization technology. In Section III an overview of OpenStack, Eucalyptus, OpenNebula, and CloudStack is provided. Section IV provides a comparison of all above said open source platform by considering various parameters and the paper concludes in Section V.

II. VIRTUALIZATION

Virtualization is a virtual copy of server, desktop, storage, OS and network which share single physical instance among multiple users. The Virtual Machine (VM) or instance is known as Guest machine and the machine on which this VM is created is referred to as the Host machine. Virtualization is of four types: a) In Hardware virtualization, the hypervisor or virtual machine is installed directly on hardware system, b) In Operating system virtualization, the hypervisor is installed on the host operating system, c) In server virtualization, the hypervisor is installed on the server system for using multiple servers from single physical server and d) In storage virtualization, the physical storage from multiple storage devices in the network is grouped together and it is mainly used in recovery and backup purposes.[3]

III. OPEN SOURCE CLOUD TOOLS

This section provides a brief description of most common open source cloud platforms: OpenStack, Eucalyptus, OpenNebula, and CloudStack by highlighting their architecture.

A. OpenStack

OpenStack is a combination of multiple open source IaaS projects for developing private and public clouds which are initiated by Rackspace and NASA in the year 2010. The components of OpenStack are: Nova(compute), Swift(Storage), Imaging service(Glance), Neutron(Network), Horizon(Dashboard), Keystone(Identity), Cinder(Block storage). Nova is for creating and managing virtual machines and to provide object storage. Swift provides cloud storage for storing and accessing the objects. Glance offers a repository of VM images which can be used as templates when deploying VM instances. Neutron provides necessary networking services for communication within VMs and also manages the network and IP addresses. Horizon is the important component providing dashboard service for administrator and users. Keystone provides cloud identity services among the list of users. Cinder offer block level of storage for OpenStack compute instances. [4][5][6][10][11].

B. Eucalyptus

Eucalyptus is an open source cloud computing platform for installing private and hybrid clouds. It stands for Elastic Utility Architecture for Linking Your Program to Useful Systems. Eucalyptus mimics Amazon Web Services EC2 for creating private clouds. Eucalyptus has five main components: Cloud controller(CLC), Cluster controller(CC), Storage controller(SC), VMware Broker and Node Controller(NC). Cloud controller acts as a web-based administrative interface to query other components for any request and information. It manages the virtual resources in the cloud infrastructure. Cluster controller controls and manages one or more Node controller and also the instances deployed in the node controller. Since it has to communicate between cloud controller and node controller, it manages the network connectivity. Storage controller provides block-level storage to be used by the VM instances. It communicates between cluster controller and a node controller for managing the snapshots from VM volumes. It mimics the Amazon Elastic Block store. Node controller is installed on each node (VM) in the cloud infrastructure and controls VM activities such as start-up, check, shutdown, and clear-up. VMware Broker interacts between cloud controller and VMware for connectivity between ESXi and vCenter server. [4][5][7].

C. OpenNebula

OpenNebula is an open source IaaS cloud computing platform for heterogeneous distributed applications for creating private, public and hybrid clouds. OpenNebula was initially released in 2008 and in later March 2010, the main authors of OpenNebula had founded C12 labs for providing value added professional services. OpenNebula has cluster type architecture which consists of Front-end to run all the services of OpenNebula, Host virtual machines, Cluster with a pool of hosts sharing common data stores, networks and Image Repository for storing the VM images in the cloud. It has Oned to provide compute resources such as CPU, memory etc., It uses Sunstone as a dashboard for providing UI to administrators and users. The virtual network manager is responsible for network connectivity between all the components. The storage for accessing and storing cloud objects is provided internally. The main features of OpenNebula are integration, management, scalability, security, and accounting. [5][8][12].

D. CloudStack

Cloudstack was initially developed by cloud.com in 2010. After that, Citrix purchased cloud.com in 2011 and in 2012 Citrix donated cloudstack to Apache software foundation installation of Apache cloudstack consists of two parts: Management server and cloud infrastructure. Management server manages cloud resources, VM creation, VM management, assigning IP addresses to the VM and provides API for administrators and users. Cloud infrastructure has the following components: Regions with one or more zones, Zones consists of one or more pods and secondary storage, Pod with one or more clusters, Cluster with one or more hosts and primary storage and Host with a compute node. The functions of all above mentioned components are: Region is the largest unit in the cloudstack deployment which is used for fault tolerance and to achieve availability and scalability, Zone is to represent geographical location for allocation of VMs, Pod is a rack of hardware, Cluster is a group of multiple similar hosts, Primary storage is used in every cluster for storing disk volumes and VM instances, and secondary storage is used for storing VM images and snapshots. [4][5][9].

IV. FEATURE COMPARISON

Features	Eucalyptus	OpenStack	OpenNebula	CloudStack
Origin	2008, Santa Barbara Eucalyptus system company	2010, Rackspace, NASA, Dell, Citrix, Cisco, Canonical etc.,	2008, European Union	2010, Cloud.com
Architecture	Cloud controller, Walrus, Cluster controller, Node controller, Storage controller, Minimum 2 server	Compute(Nova), Object Storage(Swift), Image Service(Glance)	Classical cluster, Minimum 2 server	Monolithic architecture
Structure	Hierarchical	Distributed	Centralized	Hierarchical
Cloud Service Model	IaaS	IaaS	IaaS	IaaS
Managed by	Eucalyptus Systems	OpenStack foundation	C12G Labs	Apache Software Foundations
Hypervisor	KVM, XEN, VMware in the enterprise edition,	KVM, VMware, XEN, LXC, QEMU, vSphere, Microsoft hyperV, UML, Virtualbox	KVM, VMware, XEN	KVM, VMware, XEN, Virtual box
Programming Languages	Java, C, Python	Python, XML, Javascript	C++, C, Ruby, Java, Shell script	Java, Python
OS Support	GNU/Linux can host Linux and Windows VMs	CentOS, Debian, Fedora, RHEL, Open SUSE, SLES and Ubuntu	CentOS, Debian, Fedora, RHEL, Open SUSE, SLES and Ubuntu	GNU/Linux can host Linux and Windows and BSD for guest VMs
Databases	Postgre SQL	SQLite3, MySQL and Postgre	SQLite and MySQL	MySQL
User Interfaces	euca2ools(CLI)	Web interface and CLI to deploy VMs and a console to manage the VMs	Web Interface and CLI	Web Interface and CLI
DevOps deployment	Chef, Puppet	Chef, Crowbar, Puppet	Chef, Puppet	Chef, Puppet
Compatible with	AWS EC2, S3	AWS EC2, S3, EBS and OCCI	AWS EC2, S3, Native XML, RPC, OCCI	AWS EC2
Cloud types	Private, Hybrid Cloud	Public, Private & Hybrid Cloud	Public, Private & Hybrid Cloud	Public & Private Cloud
SSH management	SSH	SSH	SSH or NFS	SSH
VMs location	Node controller	Compute node	Cluster node	Cluster node
Networking	Managed, Managed-noVLAN, system, static	Flat, DHCP, VLAN	VLAN	Flat, VLAN
Storage	Volume and Object storage	Volume and Object storage	Volume storage	Volume and Object storage
License	GPL	Apache License 2.0	Apache License 2.0	Apache License 2.0
Load Balancing	Cloud controller	Cloud controller	Ngnix	TCP Load balancer
Fault Tolerance	Separate cluster reduces the chance of correlated failures	Use Swift	Persistent database backend to store host and VM information	Using regions with multiple zones
Security	Cloud controller generates a public/private key code pairing for user authentication	API includes protection against DoS attack or faulty clients. Allow admin to manage other accounts. Keystone is used for identity management	Authentication by passwords, secure shell & RSA key code pairing or Lightweight direct access protocol. Multi tenancy for public clouds	Cloudstack security groups
Authentication	X509	X509, LDAP	X509, LDAP, SSH RSA, Key pair, password	X509

V. CONCLUSION

Open source cloud platform is available in large number with various specifications for both academic and industrial purposes. Based on the user requirement, selecting appropriate platform is quite confusing and tedious task. This paper presents unique and brief characteristics comparison on Eucalyptus, OpenStack, OpenNebula and CloudStack in terms of architecture, networking, hypervisor, and security etc. This review paper avoids the need to search for IaaS frameworks from largely available group. This comparative study will help the researchers to select appropriate platform

by understanding strengths and limitations of each platform based on their requirement.

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