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OpenStack: Toward an Open-Source Solution for Cloud Computing

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ABSTRACT

Cloud computing is a quite new concept for which the resources are virtualized, dynamically extended and provided as a service on the Internet. In this paper, we present a comparative study between some of the IaaS (Infrastructure as a Service) commonly used to select the best suited one for deployment and research development in the field of cloud computing. The aim is to provide the computer industry with the opportunity to build a hosting architecture, massively scalable which is *completely open source*, while overcoming the constraints and the use of proprietary technologies. Then, we present the solution OpenStack retained by the comparative study. We discuss in detail its functional and architectural system. We finish by a discussion of the motivation of our choice of the IaaS solution.

General Terms:

OpenStack, IaaS

Keywords:

Opencloud, IAAS, OpenStack, Eucalyptus, OpenNebula, Virtualization, Scalableifx

1. INTRODUCTION

Cloud computing is relatively a new concept that brings together all the disciplines, technologies (Web services, virtualization, SOA: service oriented architecture, grid computing,...) and business models used to deliver IT capabilities (software, platforms, hardware) as a service request, scalable and elastic [21]. This is the new trend of computing where IT resources are dynamically scalable, virtualized and exposed as a service on the Internet [7].
Cloud computing is often associated with the supply of new mechanisms that allow providers to give users access to a virtually unlimited number of resources (*Resource Outsourcing*). It also uses billing mechanisms to use these resources on the basis of their consumption, allowing on-demand model: *pay-per-use* [7]. Warranties are offered by the infrastructure provider through tailored service contract: *Service Level Agreements* (SLA) [7].
Today, all major industry players offer cloud solutions, especially Amazon EC2, Microsoft Azure, Google Apps and IBM blue cloud [20].
Cloud computing consists of three levels of offerings: [7]

(1) Infrastructure as a Service (IaaS), where the equipment is provided in the form of virtual machines. The client maintains the applications, runtimes, integration SOA (Service Oriented Architecture), databases, server software while the supplier maintains the Cloud virtualization, hardware server, storage, networks. Among the main actors of IaaS we find Amazon EC2, Rackspace, GoGrid.
(2) Platform as a Service (PaaS), you can develop your own applications using the services provided. The client maintains only those applications while the supplier maintains the runtimes Cloud, SOA integration, databases, server software, virtualization, server hardware and the storage networks. We have among the key players: Google Apps Engine, Windows Azure.
(3) Software as a Service (SaaS), the entire applications are available remotely. Among the providers we have GoogleApps, salesforce, facebook.

The three levels of cloud offering are shown in figure 1, the lower level is the computer hardware resources (computing, storage, network), and mechanisms called virtualization hypervisor, which virtualize access to the material resources of a physical machine (processor, memory and other devices). The interest of a hypervisor is to dynamically add or remove instances of virtual servers on one physical server. This is done using the tools of services and interfaces management. The upper level represents the interactions between the users of the services and the cloud.
Currently, several proprietary and some open source solutions exist, but are not easily amenable to experimentation or instrumentation. Researchers interested in pursuing studies on Cloud Computing IaaS have few tools to work with.
In this paper, from a comparative study of existing IaaS solutions, we propose an open source cloud platform, modular and *totally open*, for any use including research. The paper is organized as follows. First, we compare the different IaaS solutions. Then, we present the OpenStack platform adopted by this comparative study. After that, we present the different works done on IaaS solutions. Finally, we conclude with a general summary and possible future works.

2. EXISTING STUDIES

The main studies about IaaS solutions focused on two sides, the study of middleware platforms and on the comparative studies of the different solutions. Eucalyptus [4, 13], OpenNebula [1, 14] and Nimbus[11] have been largely studied in the literature. In these works, the architecture and various components of these solutions were presented. There are also comparative studies of different solutions [18, 22]. In [1, 11, 13], it is essentially an overview of the solutions Eucalyptus, Nimbusm OpenNebula and a presentation of their different characteristics. In [18, 22], comparative studies of Eucalyptus, Nimbus and OpenNebula, including characteristics, architectures and applications are done in order to provide more freedom of choice for the users of the cloud. Concerning OpenStack, little work has addressed this solution [10]. We find in [10] a comparative study of Eucalyptus, Nimbus and OpenNebula. This study, from 2011 is outdated. OpenStack has since then evolved, requiring an update. Recently, G. von Laszewski [5] outlined the differences between Eucalyptus IaaS platforms, OpenNebula, Nimbus and OpenStack. The focus is on the look and feel interface, storage

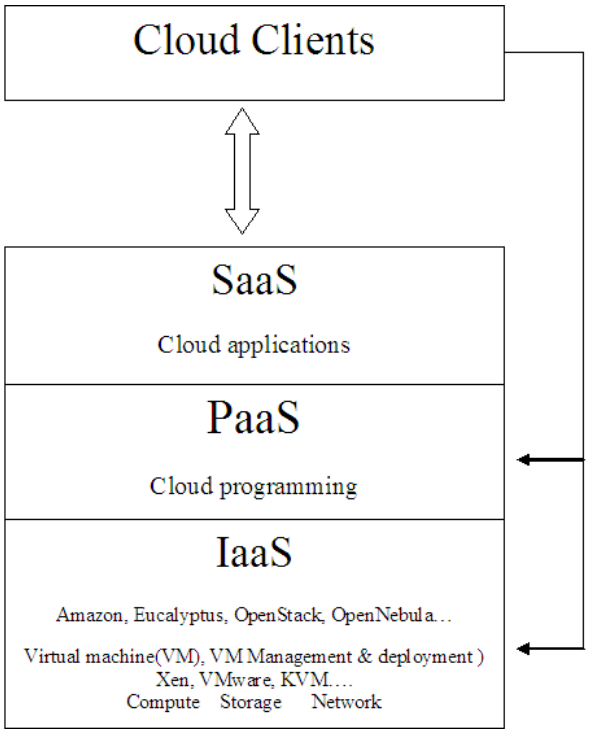

Fig. 1. General architecture of the Cloud.

Fig. 2. Using OpenStack and Eucalyptus by Country 2011-2012 [6].

and network usage in a project called FuturGrid. The *openness* of the cloud is not addressed.

3. COMPARATIVE STUDY OF CLOUD SOLUTIONS

Different solutions exist for the deployment of open source clouds. Among these, we have Nimbus, Eucalyptus, OpenStack and OpenNebula. We propose a comparative study of the last three solutions in order to select the most appropriate solution to our criteria. These include popularity, community use, modularity, openness, open source. Figures 2 and 3show a comparison of the solutions using Eucalyptus, OpenStack and OpenNebula in all countries between April 2010 and April 2012 and the interest of some countries to these solutions [6].

3.1 Eucalyptus

Eucalyptus is a solution that allows the installation of a private and hybrid cloud infrastructure. It is written in Java language, C and Python, with a main storage controller walrus and controllers on each node. The network is managed by the component cloud controller and each controller is authenticated by SSH key files and permission to authenticate transactions. Eucalyptus scalability is limited, compared to the massive scalability, and the source code of some of its modules are closed. This is why it is being abandoned for other solutions. Eucalyptus is the platform used by Amazon EC2.

3.2 OpenNebula

OpenNebula is another cloud solution, it is open source under Apache 2 license. It is written in C++, Ruby and Shell. The network is managed manually by the administrator. Storage, the default copy of the virtual machines are accessed via SSH. OpenNebula supports authentication via LDAP. OpenNebula is the recommended platform for Europe and developed by a Spanish company. It is an easy to use solution for Data Centers and Private Cloud.

3.3 OpenStack

OpenStack solution is recent and under active development. It has great potential due to its architecture and community and the support of its partners. All code is licensed under Apache 2 license. OpenStack is a platform developed by NASA dedicated to massive infrastructures.
OpenStack main characteristics are that is :

—*Scalable*: This solution is already deployed worldwide in companies whose data volumes is measured in petabytes of distributed architectures and massively scalable up to 1 million physical machines, up to 60 million virtual machines and billions of stored objects [8].

—*Compatible and Flexible*: OpenStack supports most virtualization solutions of the market: ESX, Hyper-V, KVM, LXC, QEMU, UML, Xen and XenServer [2, 20].

—*Open*: Being an open source technology, the entire code can be modified and adapted as needed. The project OpenStack also presents a validation process for the adoption and development of new standards.

This project is supported by many companies in the world (mainly in the U.S.) and is based on the code used by NASA and Rackspace Cloud. It is written in python and currently implements two control APIs, the EC2 API and Rackspace. It uses different drivers to interface with a maximum number of hypervisors (Xen, KVM, HyperV, Qemu) [16]. This project is dedicated to providing the computer industry with the opportunity to build a hosting architecture and massive scalability and is completely open source, while it overcomes the constraints of the use of proprietary technologies. According to this comparative study, it appears that the best solution is OpenStack, it can become the reference solution of open source cloud computing because of its characteristics.

4. OPENSTACK ARCHITECTURE

OpenStack architecture is built using three main components: OpenStack Compute, Image and Object (see figure 4). In this section, we will explain in detail these components and we will describe other components of OpenStack.

4.1 OpenStack Compute

OpenStack Compute, also known as Nova, is a management platform that controls the infrastructure to control IaaS clouds.

Fig. 3. Comparative solutions Cloud 2010- 2012 [6].

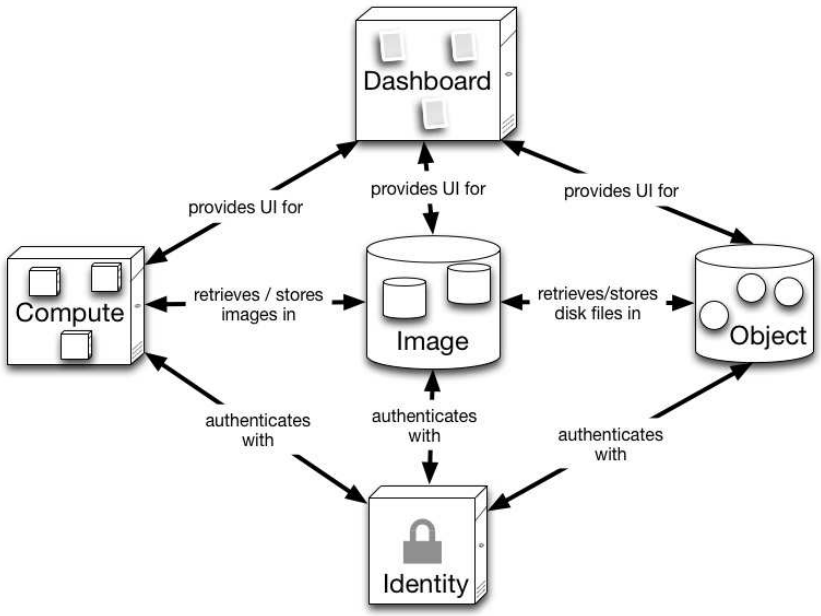

Fig. 4. OpenStack Architecture [9].

Table 1. Comparative study of IAAS solution .

	Solutions cloud computing IAAS		
	Eucalyptus	OpenNebula	OpenStack
Storage	+ + + + +	+ + +	+ + + + +
Network	+ + + +	+ + + +	+ + + + +
Security	+ + + +	+ + +	+ + + + +
Hypervisor	+ + + +	+ + +	+ + + +
Scalable	+ + +	+ + + +	+ + + + +
Installation	+ +	+ + +	+ + + + +
Documentation	+ + +	+ + +	+ + + + +
Code and License	+ + +	+ + + + +	+ + + + +

It is similar in scope to Amazon EC2 [11] and Rackspace CloudServers [12]. Nova Compute allows managing large networks of virtual machines and redundant and scalable architectures. It provides an administrative interface and an API needed for the orchestration of the Cloud. It includes instances management for servers, networks and access control. Compute requires no prerequisite hardware and is completely independent of the hypervisor

Nova consists of seven main components (Figure 5). At first, we have the API Server, which is considered the heart of Nova. It acts as the Web front end service control of the hypervisor. Then, we find the Message Queue that implements the mechanism for dispatching the exchanged instructions to facilitate communication. After that, Compute Controller handles the lifecycle of instances, it is responsible for creating and manipulating virtual servers, while the component Object Store provides storage services. Volume Controller component handles the assignment, attachment and manipulation of volumes. While the network Controller is responsible for the creation of Bridges / VLAN / DHCP / DNS and firewall rules. Finally, Scheduler distributes tasks and determines where they should be executed.

4.2 OpenStack Imaging Service

Imaging Service (project Glance) provides storage services, recording and distributing the images to virtual machine disks. It also provides an API compatible with the REST architecture to perform queries for information on the images hosted on different storage systems.

4.3 OpenStack Object Storage

Object Storage (Swift project) is used to create a storage space redundant and scalable for storing multiple petabytes of data. It's not really a file system but is especially designed for long term storage of large volumes. It uses a distributed architecture with multiple access points to avoid SPOF (Single Point of Failure).

4.4 Other components

Features are added to fill a missing service or improve an existing one like:

—OpenStack Dashboard - horizon

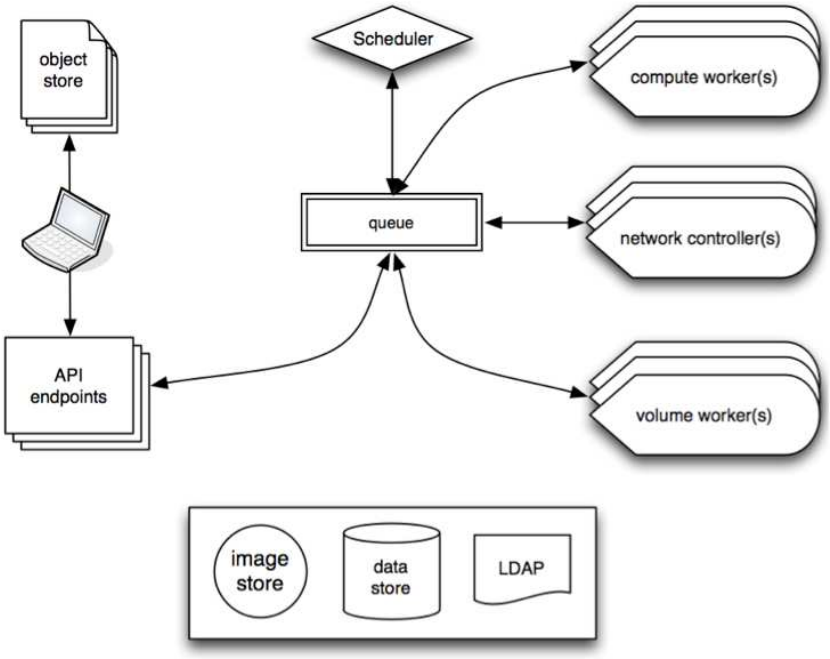

Fig. 5. Nova system architecture [9].

—Keystone, Identity Service for OpenStack. It is the authentication system of OpenStack. This new component is emerging to address the problem of authentication and authorization of OpenStack.

—Quantum, OpenStack Virtual Networking and Atlas, OpenStack Load Balancer.

4.5 Discussion

Several considerations should be taken to determine the best suited solution for the implementation of a cloud platform.
In addition to the aspects discussed in the previous section, respecting the openness and scalability criterea. We insist on two very important points : Opensource and support for new standards.
From the beginning, OpenStack was completely open source. Eucalyptus recently opened its source code but the development of additional plugin is still commercial.
For a purely open source policy, OpenStack seems to follow the trends dictated either by the needs of users or by compliance with the new open standards. Thus Openstack has proposed a support for the OpenFlow standard [19]. The same applies to OpenNebula, but indirectly with the usage of Open vSwitch [15] [17]. While Eucalyptus has not yet supported this very promising standard.

5. CONCLUSION

OpenStack is designed to allow administrators and researchers to deploy IaaS infrastructure and provide tools for creating and managing virtual machines on top of existing resources. This work aims to illustrate that the system OpenStack has filled an important niche in the design space of cloud computing by providing an easy to deploy over the existing resources, easy to use in experimentation by being modular, and most importantly forms*open source* and provides powerful features while following emerging open standards. Currently, we deployed the entire system. This system will be used in future works to study and evaluate its performances in dynamic reconfiguration in a IaaS Cloud Computing.

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