Tesfamicael, Aklilu Daniel, Liu, Vicky, & Caelli, William
(2015)
Design and implementation of unified communications as a service based on the OpenStack cloud environment. In
Proceedings of the 2015 IEEE International Conference on Computational Intelligence & Communication Technology (CICT), IEEE, Ghaziabad U.P., India, pp. 117-122.

http://dx.doi.org/10.1109/CICT.2015.133

Design and Implementation of Unified Communications as a Service based on the OpenStack Cloud Environment

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***Abstract*— Cloud Computing, based on early virtual computer concepts and technologies, is now itself a maturing technology in the marketplace and it has revolutionized the IT industry, being the powerful platform that many businesses are choosing to migrate their in-premises IT services onto. Cloud solution has the potential to reduce the capital and operational expenses associated with deploying IT services on their own. In this study, we have implemented our own private cloud solution, infrastructure as a service (IaaS), using the OpenStack platform with high availability and a dynamic resource allocation mechanism. Besides, we have hosted unified communication as a service (UCaaS) in the underlying IaaS and successfully tested voice over IP (VoIP), video conferencing, voice mail and instant messaging (IM) with clients located at the remote site. The proposed solution has been developed in order to give advice to bussinesses that want to build their own cloud environment, IaaS and host cloud services and applicatons in the cloud. This paper also aims at providing an alternate option for proprietary cloud solutions for service providers to consider.**

***Keywords*— UCaaS; IaaS; Private Cloud; Hybrid Cloud; OpenStack; VoIP .**

I. Introduction

Cloud computing gives businesses on-demand, fast access to a variety of IT services, software and applications while also giving businesses a shared pool of configurable computing resources at the platform, infrastructure and application layers. Thus cloud technology helps businesses do more and act faster by giving them the option to select IT services without having to fully fund, build, manage or maintain them. Small and Medium business (SMBs) would prefer a "pay as you go" method for funding ICT services in the cloud as this is cheaper for them. However, some large organizations may prefer to build their own private, public or hybrid cloud environment.

In recent years, the need for movement to a cloud solution environment has gained more attention and as a result most organizations are looking onto ways of moving into cloud. Recently, the Queensland Government in Australia has announced their ICT strategy to make Queensland Government a "cloud-first" enterprise [1]. This will require proper planning going forward and decisions on the selection of cloud providers so that they can successfully migrate datacentres to IaaS, "infrastructure as a service", and their IT services and applications to equivalent services in the cloud. However, to boost business confidence in this area there is a need for more research so that the customers may have a clear understanding of what cloud technology can provide to them and under what trust environments.

In this paper, we report on an implemented private cloud environment based on an open source platform, viz. "OpenStack" with hosted UCaaS to provide cloud based UC services. Some leading cloud providers such as Amazon, Microsoft and Google are providing scalable on-demand infrastructure that seems to be gaining market place momentum [2]. However, these proprietary (commercial) clouds usually charge a high price through their associated, retail cloud service providers, based on a customer's use of resources. Hence, it may be more suitable for some organizations, particularly small and medium enterprises, both public and private, to build their own cloud solution based on freely available cloud software solution operating on commodity server hardware. That is the reason why open-source cloud platforms are growing faster as an alternate to proprietary cloud solution. Major security and trust considerations may also apply.

This research is aimed at giving advice to businesses that want to build their own IaaS and host their own cloud services and applications, and to service providers to look on an alternative solution to proprietary cloud solutions. Underlying hardware systems may be owned or leased.

In the next section we discuss related work followed by an overview of the OpenStack Architecture in Section III. Section IV discusses the deployment of UCaaS. Our cloud implementation test bed is described in Section V. In Section VI we provide a description and analysis of the design experiment followed by some conclusions and suggestions for future work in Section VII.

II. RELATED WORK

There are numerous studies focused on the open source cloud solution. However, at the time of writing this paper and during our literature review we have not found any published paper that discusses UCaaS or Voice over IP as a service (VoIPaaS) in an open source cloud platform.

In 2012, W. Xiaolon *et al.* [3] performed a study comparing two popular cloud, open source platforms, viz. "OpenStack" and "OpenNebula". They examined these two products from different angles in comparing their provenance, architecture, hypervisors and security. This study may influence further study in the area. However, there is no experimental evidence to verify their proposals. It would have been an ideal solution if both OpenStack and OpenNebula had been implemented in virtual or dedicated physical hosts to provide experimental performance results to support their proposals.

In 2014, R. Nasim and A. J. Kassler [4] deployed OpenStack in a virtual infrastructure and dedicated hardware to observe performance parameters. The result from this type of study can support decision making when selecting the underlined hardware in deploying OpenStack. Though this solution was deployed on a small scale the paper demonstrated OpenStack deployed over dedicated hardware always performs better than OpenStack running over a virtualized environment due to overheads from computational resource usages.

There are other studies [5]-[12] that focus on architecture designs and OpenStack performance analysis and these have indicated that there is a great interest in this area.

T. Rosado and J. Bernardino in [13] have produced a paper discussing OpenStack Architecture. However, there is no original work offered in this paper.

In recent years' researchers have delivered major research papers on open source cloud solutions that are promising. However, there is a need for more research beyond consideration of any underlying infrastructure to understand the deployment and performance of applications and other services hosted on the underlying IaaS platform. This paper is different from those reviewed as it has mainly focused on the implementation of the underlying architecture of Openstack, that forms the base for "Infrastructure as a Service" (IaaS) and the deployment of other cloud services such as UCaaS, hosted in that open source cloud environment.

III. OPENSTACK ARCHITECTURE

OpenStack is an open source cloud computing project aimed at deployment in all types of cloud environments. Globally, cloud computing experts contribute to this project to make its implementation simple and scalable [14]. Openstack provide such IaaS solution through different forms of services. The simplified architecture of OpenStack, and its components that form IaaS, is shown in Fig. 1.

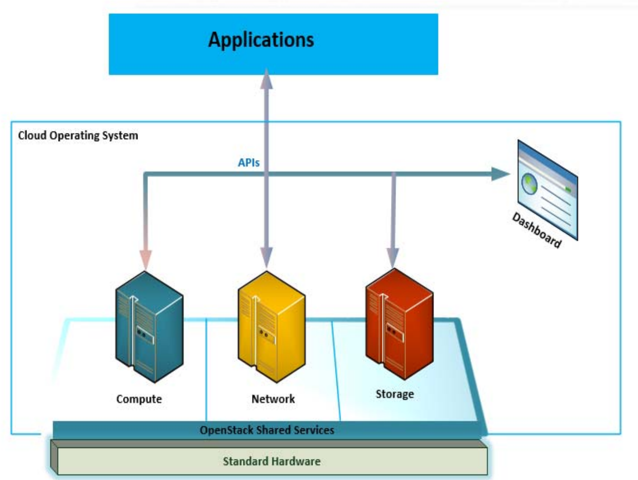

Fig. 1. OpenStack Architecture

The main components of the openstack cloud model are controller, compute and network nodes.

A. Controller Node

The Controller Node hosts all OpenStack services needed to orchestrate virtual machines deployed on the Compute Nodes [14]. For high availability it is recommended to deploy at least three controllers to provide multiple controller nodes. The controller node is illustrated in Fig. 2.

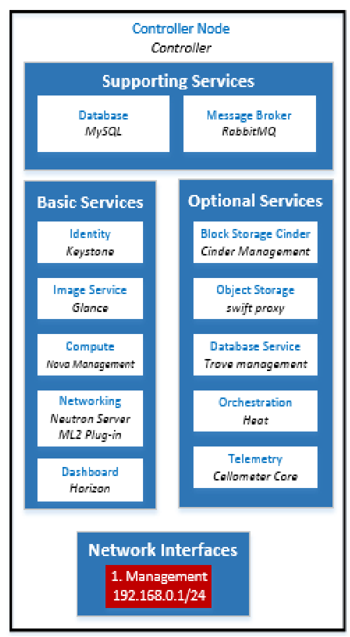

Fig. 2. Controller Node in OpenStack Architecture

B. Compute Node

Compute Node is, in many ways, the foundation of the environment; it is the server on which virtual hosts are created and applications are hosted. Compute nodes need to communicate with controller nodes and access essential services such as MySQL. The compute node is shown in Fig. 3.

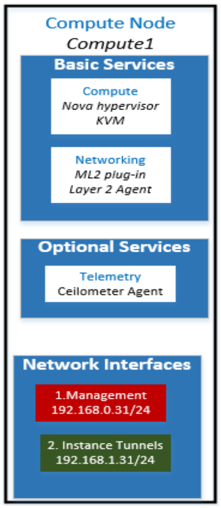

Fig. 3. Compute Node in OpenStack Architecture

C. Network Node

An OpenStack environment includes multiple servers that need to communicate with each other and to the outside world and this node serves that purpose. It supports both old "nova-network" and new "neutron" based OpenStack networking implementations as illustrated in Fig. 4.

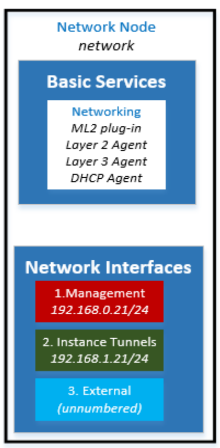

Fig. 4. Network Node in OpenStack Architecture

Many proprietary cloud service providers have already started to show interest in the OpenStack solution. For example, Cisco Inc. has recently managed to integrate emerging OpenStack cloud solution with their cisco unified computing system (Cisco UCS) and Nexus platforms [15].

IV. UCAAS DEPLOYMENT

The deployment of UC in-premises is becoming more complicated and expensive [16]. To avoid this, businesses are looking to the cloud as an outsourcing option. UCaaS gives businesses quick access to current business collaboration tools. UC service providers often offer multi-tenant cloud services. This UC model is appropriate for smaller or medium business (SMBs) because of its flexible pricing. Large businesses that require their own cloud environment may benefit from the proposal outlined here better than SMBs. Cloud service providers may also look on this proposal as an alternative solution for their proprietary cloud offerings. Our high level IaaS and UCaaS design overview is shown in Fig. 5.

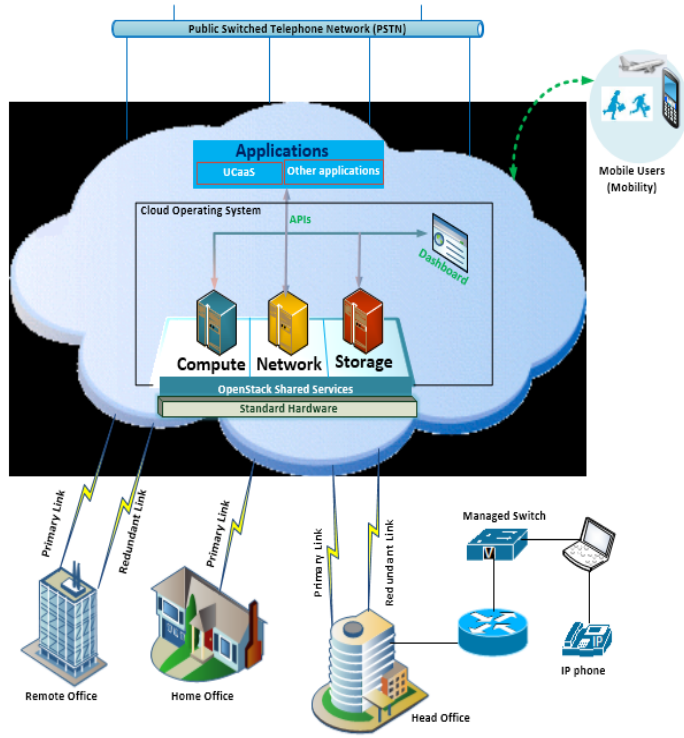

Fig. 5. Our IaaS and UCaaS High Level Design Overview

V. OUR PRIVATE CLOUD AND UCAAS IMPLEMENTATION TEST BED

This section describes OpenStack and UCaaS implementations with dedicated hardware for the implementation of IaaS and the deployment of UCaaS to be hosted as a cloud service. For ease of deployment in this test bed we have deployed openstack in one computer, all-in-one, acting as controller, network and compute nodes as described in Table I.

OpenStack can also be deployed in a virtual environment [4]. For a single-machine installation, the following minimum system specifications are recommended.

- CPU that supports VT-x/AMD-V. Quad-core or better

- 12GB memory or above
- 100GB of hard drive or more
- Juju version 1.18.3 or higher
- Ubuntu 14.04 LTS, 64-bit version

In real world deployments we highly recommend this design proposal to be deployed in a multi-server solution to avoid a high potential for single point failure and performance bottlenecks. In future work we will be examining the deployment of the OpenStack cloud in a multi-server platform to analyse the QoS and perform system performances tests.

TABLE I. HARDWARE SPECIFICATIONS OF EXPERIMENTAL DEVICES

2 Hosts	1 Switch	1 Router
Host 1 – All-in-One OpenStack Processor: Intel Core i7-3770 CPU, 3.40 GHz x 8 Installed memory (RAM): 16 GB Storage: 500GB OS type: Ubuntu 14.04 LTS 64bit **Host 2 – Management** Processor: Core 2 duo, 2.33 GHz Installed memory (RAM): 4 GB Storage: 80GB	Cisco Catalyst 3560 Switch	Cisco 2911 Integrated Services Router

A. *OpenStack deployment components*

In our test bed we implemented three core components of Infrastructure as a service (IaaS) as discussed in section III. These resources are integrated in a cloud environment to deliver cloud services. The cloud deployment under this model can be delivered in an "all-in-one" host (installed in a virtual or physical host) or in a multi host configuration.

B. *UCaaS deployment components*

We have used "Asterisk" unified communication software for our experiment, which is installed on a cloud virtualized host within OpenStack. This Asterisk software provides voice over IP as a service (VoIPaaS), video conferencing as a service (VaaS) and messaging as a service (MaaS). All UCaaS features over the cloud profoundly depend on quality of service (QoS), storage and streaming protocols. Though this experiment focuses on a design and deployment discussion of these services in the cloud, in future work we will be testing the QoS and performance aspects of these hosts over the cloud environment, which is the vital part in considering hosting UC in the cloud.

VI. DESCRIPTION AND ANALYSIS OF THE EXPERIMENTAL DESIGN

To demonstrate the feasibility of the proposed implementation of our private cloud solution using OpenStack we setup an all-in-one server with dual network interfaces (NIC) connected to the internet via an integrated service router, a "Cisco 2821" unit. This server is running Ubuntu 14.04 TLS 64bit as an operating system. We have also used "juju" which is a powerful GUI and command line tool that helps configure, manage, maintain and deploy an OpenStack cloud using "charms". Juju charms define how services are connected to each other, scaled and deployed and they also contain configuration settings of an application. Juju admin GUI for management of the cloud services is shown in Fig. 6

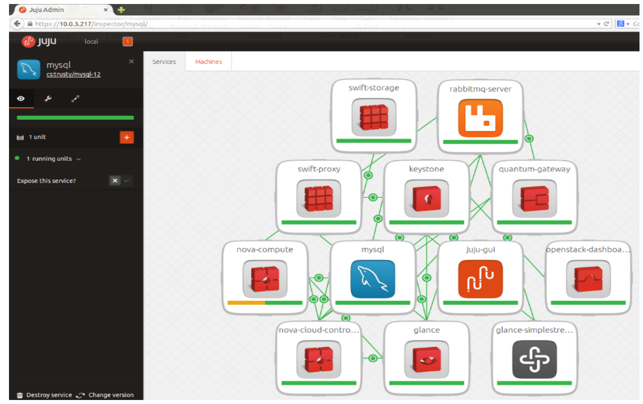

Fig. 6. Our juju admin GUI Overview

The juju OpenStack package deploys the core open cloud hosts: controller, network and compute nodes. Using the compute node we created a new virtual host and deployed cloud version "Asterisk" package on this host to serve as UCaaS as shown in Fig. 7.

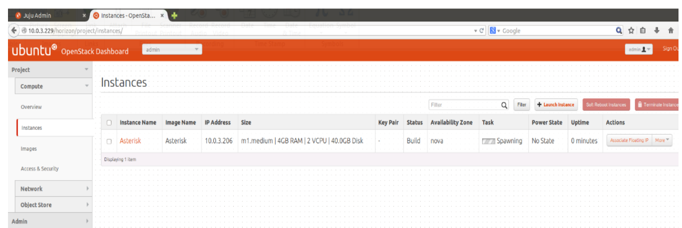

Fig. 7. Our Deployment of Asterisk in OpenStack

The single machine is capable of holding the entire stack in a single LXC container, also known as a Linux container. The deployment within the stack allows us a quick test of a new OpenStack deployment. On a different network, external to the cloud environment, we also installed and configured X-Lite as softphones in two of our laptops at a remote site that are configured and registered with the Asterisk server in the cloud environment. We have successfully demonstrated a voice and video call, voice message delivery as well as the exchange of instant messaging between the two laptops. Fig. 8 shows the successful voice to voice call over the cloud (VoIPaaS) between the two softphones installed on separate laptops in the remote office.

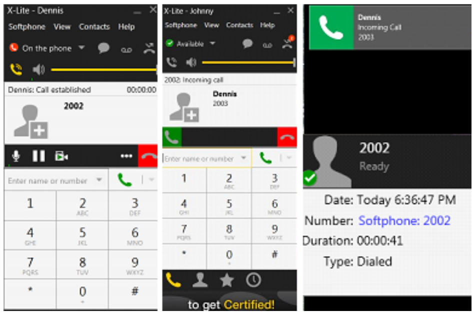

Fig. 8. Our Voice to Voice Call Over the Cloud (VoIPaaS)

Similarly we have managed to make a video call between the two laptops with X-Lite installed on them. Fig. 9. shows the successful video to video call over the cloud (VaaS) between the two softphones installed on separate laptops in the remote office.

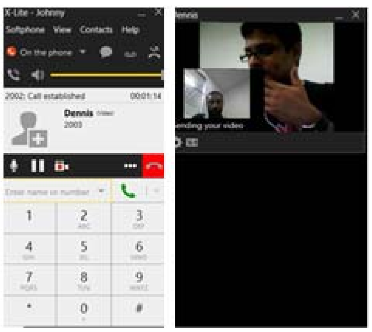

Fig. 9. Our Video to Video Call over the Cloud (VaaS)

This test demonstrated the successful implementation of IaaS using an opensource cloud solution called OpenStack and UCaaS using the Asterisk server. We have also successfully deployed softphones in the remote office connected directly to Asterisk server in the cloud.

VII. CONCLUSION AND FUTURE WORK

The design and implementation we have discussed in this paper is easy to deploy and the cost associated with its implementation is greatly reduced due to its “free to use” software license. It also avoids proprietary lock-ins from product vendors. One of our recommendations, which is based on the experimental experience, is that the deployment and configuration of this open source cloud solution can be achieved by people with no prior knowledge or experience of cloud technologies.

We submit that this research paper provides useful advice to businesses that want to build their own cloud environment and host their own services and applications. We also believe this contributes to knowledge for cloud service providers to understand the alternative solutions to proprietary cloud products, systems and services.

In future work we will be studying the deployment of Openstack on a multi-server platform and investigate enhanced security architectures for UC positioning in a cloud environment. We will also providing a performance analysis of the core open source cloud hosts and the QoS of the dependent network in delivering voice and video services over the cloud.

ACKNOWLEDGMENT

Our IaaS and UCaaS implementation experiment has been conducted in a university based network laboratory with student teams. The Authors appreciate the contributions from Daniel Huang and Wang Shuai on conducting the OpenStack installation.

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