A Comparative Study of OpenStack and CloudStack

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***Abstract*—Even though of its very recent origins, Cloud Computing has matured into a main stream technology over the past few years. Private cloud, where an organization sets up an internal cloud infrastructure, is gaining traction these days because of its perceived security advantages. Two of the major open source cloud middlewares are OpenStack and CloudStack. This paper provides a comparative study of these two cloud middlewares regarding its implementation complexity, overall stability and performance comparison using Unixbench and Bonnie++ benchmarks. Experiment results show that OpenStack perform better in most scenarios in a single node environment. OpenStack exhibits better overall stability but at the cost of increased installation complexity.**

***Keywords*—Private Cloud, OpenStack, CloudStack**

I. Introduction

Today most of the large and small-scale businesses are turning towards cloud computing for better business IT solutions. The academic community is also adopting it for research and learning purposes. Based on the service model, cloud computing can be generally classified into three - private cloud, public cloud and hybrid cloud. Private cloud refers to cloud environment with in an organization whose services are not accessible by the public. Only permitted members within the organization can access the services of a private cloud. On the other hand the services offered by the public cloud are supposed to be accessible to the public from anywhere in the world. A mix of these two models are considered as a hybrid cloud[1].

According to the State of Cloud Report (2014) by RightScale, based on a survey among technical professionals across a broad cross-section of business organizations, at least 94% of their respondents are adopting cloud computing technologies. Interestingly almost 88% of them are using some kind of private cloud solutions for their business IT infrastructure [2]. It is noted that three out of six most popular private cloud solutions are open-source products. They are OpenStack, CloudStack and Eucalyptus, in that order [2]. This paper is a study on the installation complexity, benchmark performances and overall stability of the top two cloud middlewares in that list - OpenStack and CloudStack.

II. Background

A private cloud can be installed in an organization only with the help of a private cloud middleware. A cloud middleware is a tool that helps to setup the cloud environment which acts in the middle of cloud resources and the client and provisions those resource according to the needs of the client. There are two types of private cloud middlewares avaialble - proprietary and open-source.

The big players in private cloud business like VMWare, Microsoft, HP, IBM etc offer their own enterprise class solutions to build private cloud for an organization. But their actual code remains proprietary which restricts the customers to modify the source code to customise it for their specific needs, especially for research and academic purposes.

On the other hand, we have couple of open-source private cloud middlewares that have enough maturity, sophistication and convenience to provide reasonably good cloud infrastructure for interested parties. Most of them have developed in research circles as a natural transformation from grid computing platforms to cloud computing platforms, so very much suited for . OpenStack and CloudStack belong to this category.

A. Paper Organization and Motivation

In this paper a basic study and comparison of the above two popular private cloud middlewares are conducted and results are plotted. Both OpenStack and CloudStack are deployed in the same machine, one after another and their architectural and implementation complexities are discussed. We have also conducted performance evaluation of OpenStack and CloudStack using two benchmarks - Bonnie++ and Unixbench and the results discussed. We also make comments about their overall stability, based on our experience in working with them.

A performance benchmarking of OpenStack and CloudStack is done in [3]. However, it is mainly concerned about a comparison of cloud-management features like virtual node deployment time, deletion time, CPU utilization during deployment and deletion, etc. But in this paper, we are concerned more about the overall system health, once the cloud environment is deployed using the above cloud middlewares. We hope that this discussion will help new cloud adopters to choose the right cloud-middleware that gives better performance during run-time.

III. Comparison: Architecture & Installation

A. OpenStack

OpenStack began as a joint project of Rackspace Hosting and NASA in 2010. It is a collection of software pieces that is aimed to provide comprehensive cloud services by virtualizing network, storage and compute resources. Figure 1 shows an outline of OpenStack architecture [4]. There are mainly three nodes - Compute node for virtualization Network node for networking and Controller node for Controlling the

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environment. Internal communication between these node are through management network. Virtual machine communication between each other and to external world is through tunnel network. Then communication with external world is through external network.

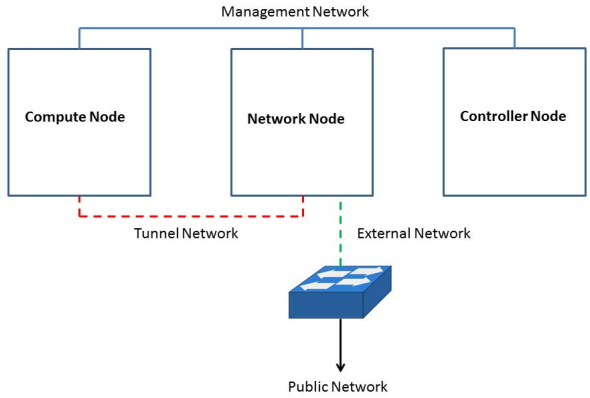

Fig. 1: OpenStack Architecture Outline

B. CloudStack

CloudStack which was originally developed by Cloud.com and later supported by Citrix. Now it is an Apache incubator project known by name apache cloudstack. Figure 2 shows a basic outline of CloudStack architecture [5]. The three nodes are 1) Supervisor node for managing the entire network and 2) VM creator for creating virtual machines and 3) Storage server for storing disk images. Here there are no separate networks for each communication. Internal communication is done through internal network and external communication is done through normal Internet.

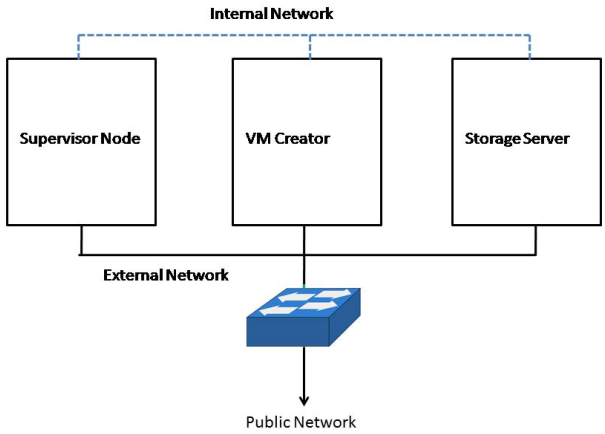

Fig. 2: CloudStack Architecture Outline

C. Single Node Installation

Both OpenStack and CloudStack have a basic installation that can be done on a single node which can host all the three functions - management, networking and computation in a single machine. OpenStack community has developed DevStack - an opinionated script for easy installation of OpenStack on a single node. In this paper, we use single node installations of OpenStack and CloudStack for performance evaluations.

	CloudStack	OpenStack
Version	4.3.2	Juno
Installation	Medium level	Difficult
Architecture	Three node Architecture with Management Server, Storage Server and Compute Server	Three node Architecture with Controller Node, Network Node and Compute Node
Hypervisor Support	XenServer, KVM, Hyper-V, Xen Cloud Platform (XCP) and VMWare	KVM, QEMU, XEN limited support for LXC,Hyper-V, VMWare
Networking	Difficult	Difficult
Storage	Separate servers maintained	Separate servers maintained
Operating System	CentOS, RHEL, ubuntu	CentOS, RHEL, ubuntu, openSUSE, Fedora
Stability	Less Stable	Highly Stable

Table 1.**Comparison Table**

D. Discussion

A general comparison of CloudStack (4.3.2) and OpenStack (Juno) are given in table 1. As mentioned earlier, the general architecture of both CloudStack and OpenStack is a three node architecture.

Regarding installation complexity, OpenStack is more difficult to deploy than that of CloudStack. This is because, OpenStack is a collection of different projects. So, we have to install and configure each projects separately and that process is comparatively difficult than that of CloudStack. That is, in CloudStack we need to bother only about configuring different servers, whereas in OpenStack we need to separately install and configure the projects in different servers.

Hypervisor is the backbone of virtualization. Both CloudStack and OpenStack have support for almost all of the leading hypervisors. But CloudStack is much more compatible with citrix XenServer since it was initailly owned by citirx. On the other hand, OpenStack provides more support for container virtualization technologies including LXC and Docker.

Both OpenStack and CloudStack warrants proper networking between the servers and clients. Networking part is difficult in both CloudStack and OpenStack. Networking includes physical switches, firewall configurations, virtual devices etc.

For storage purposes both OpenStack and CloudStack envisages separate storage servers. OpenStack has two seperate projects dealing with storage - namely, swift and cinder. In cinder Logical Volume Manager(LVM) volume groups are created for giving block storage to VM's. Swift deals with object storage. Swift is used for backup. In CloudStack a separate storage server is mounted to the management server using NFS. Regarding Operating System compatibility, both CloudStack and OpenStack support the following linux flavors: CentOS, RHEL and Ubuntu . But OpenStack has additional support for OpenSuse and Fedora.

IV. Performance Analysis

Different sets of performance tests are conducted using single node installation of CloudStack and OpenStack on

the same machine first installed with CloudStack and then with OpenStack. We used a Dell Precision T1600 4 core workstation with 8GB DDR3 memory for the purpose. Cisco 28 port gigabit managed switch is used for networking. Both CloudStack and OpenStack uses KVM as hypervisor, in this setup.

Two benchmark tools - Unixbench [7] and Bonnie++ [8] - are used to conduct the experiments.

A. *Unixbench Experiments*

Unixbench is a collection of about 10 different tests that are bundled together to provide a basic indicator of the performance of a Unix-like system. This is a system benchmark, and not a CPU, RAM or disk benchmark. That is why it is deemed to better represent the system health of a cloud middleware. A number of experiments as given in Table 2 are conducted and a final index score is generated by Unixbench based on those experiment results. Higher the index score, better will be the system health.

Unixbench experiments on CloudStack were conducted earlier in the same lab and on the same machine and the results were published in [5]. Those results are compared against freshly conducted experiments on the same machine, with OpenStack installation. Table 2 shows the comparison of UnixBench benchmarks of CloudStack with that of OpenStack.

	CloudStack	OpenStack
Dhrystone 2 using register variables	1756.2	3061.6
Double-Precision Whetstone	592.9	797.6
Execl Throughput	1166.2	1236.6
File Copy 1024 bufsize 2000 maxblocks	1675.5	3118.9
File Copy 256 bufsize 500 maxblocks	1060.8	2128.7
File Copy 4096 bufsize 8000 maxblocks	3346.7	5404.1
Pipe Throughput	1225.8	1966.2
Pipe-based Context Switching	786.4	978.5
Process Creation	1346.0	1259.3
Shell Scripts (1 concurrent)	1967.6	2270.3
Shell Scripts (8 concurrent)	1811.2	2094.7
System Call Overhead	2454.7	3324.2

Table 2.**Comparison: Unixbench Results**

Table 2 shows that OpenStack has higher index values than CloudStack in all the Unixbench benchmarks. Dhrystone index value shows that OpenStack is better than CloudStack in string handling capability. Whetstone benchmark indicates that OpenStack has better index value in performing floating point operations.

File handling tests includes reading writing and copying files using various buffer size. In this case too, OpenSatck performs better than CloudStack.

Based on these results a final index score is generated by Unixbench for both OpenStack and CloudStack (Refer Figure 3). OpenStack have comparatively high final index score than that of CloudStack. OpenStack has a high index score of 2002.2 than that of CloudStack which has scored 1443.7.

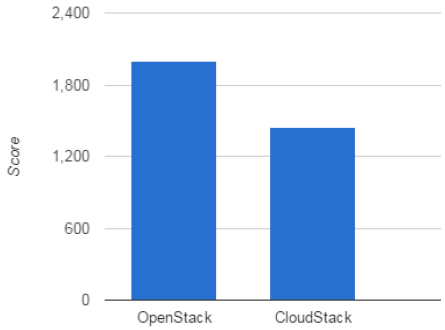

Fig. 3: UnixBench Final Index Value

B. *Bonnie++ Experiments*

Bonnie++ consists of a number of IO performance tests that will benchmark how the file systems perform with respect to data read and write speed. Dataset with a fixed size is given and multiple tests to measure the reading speed, writing speed, CPU utilization, execution speed etc are conducted. In our experiments we used a dataset of 40 MB to test both OpenStack and CloudStack environments.

Figure 4 shows the speed of writing the dataset in KB/s. It shows that there is no much difference in writing speed between CloudStack and OpenStack. For CloudStack it is about 1208 KB/s and for OpenStack it is about 1181 KB/s.

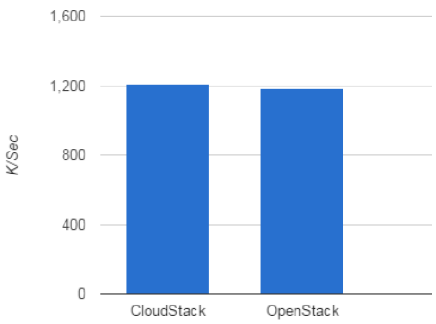

Fig. 4: File Writing

Figure 5 shows the results of testing the reading speed. CloudStack has a reading speed of 5673 KB/s and OpenStack has a reading speed of 5956 KB/s. It clearly suggests that OpenStack supports considerably faster reading speed than CloudStack. This result corroborates the higher file handling scores we received for OpenStack in Unixbench experiments.

Figure 6 shows the CPU utilization of both OpenStack and CloudStack while performing these experiments. It is calculated in percentage utilization. Both CloudStack and OpenStack have a CPU utilization of around 95%.

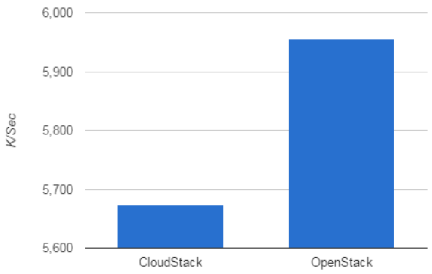

Fig. 5: File Reading

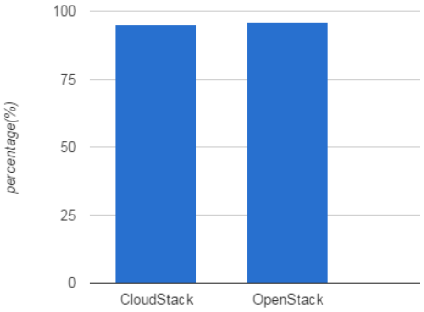

Fig. 6: CPU Utilization

Figure 7 shows the round-the-clock time taken by CloudStack and OpenStack to complete all these experiments. From the figure it is clear that OpenStack takes much lesser time than CloudStack to complete these experiments. OpenStack takes only 26159 micro seconds to complete the experiments while CloudStack takes about 44167 micro seconds.

V. Overall Stability

While working with CloudStack and OpenStack, after their installations, we felt that OpenStack is more mature and stable. One of the issues we faced with CloudStack was its inability to locate primary and secondary storage systems, once installation is complete. We found that it was mainly because of the problems in NFS mounting of Storage server. Other issue was the disappearance of working virtual machines after a reboot, in CloudStack. This seems to be a much reported issue of Cloudstack. [9]

VI. Future Works

This work is a progression of the work conducted in [5][6], where Unixbench benchmarks were tested for a single node CloudStack environment. Now we have extended that to OpenStack and further verified those results using Bonnie++ performance tool. The next step will be to conduct the same experiments in three node architectures of both CloudStack and OpenStack, which is beyond the scope of this paper.

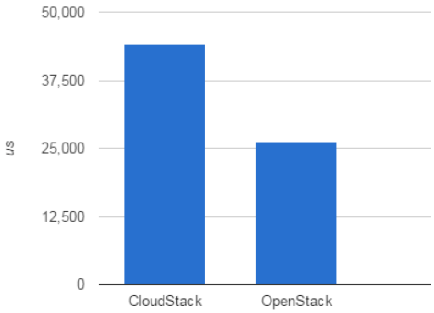

Fig. 7: Total Time

VII. Conclusion

This paper presents the general architecture and discusses the installation complexity of CloudStack and OpenStack cloud middlewares. Both CloudStack and OpenStack are architecturally similar but OpenStack seems to have higher installation complexity. But that additional effort is compensated in the better overall stability it provides against CloudStack. Both Unixbench and Bonnie++ experiments suggest that Openstack environment gives better system performance (after deployment) in almost all tested benchmarks. Moreover, we feel that the general gravitation of major community and enterprise initiatives towards OpenStack also makes it a more attractive option than CloudStack to setup a private cloud in an organization.

VIII. Acknowledgement

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