

Implementation of Private Cloud for Optimization of Computer Resources at University

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Abstract—The development of computer technology and applications are very rapid, causing the needs of computer use in the organization has increased. The performance of personal computers has increased rapidly, but it cannot be utilized properly. Therefore, personal computers can be used together to perform parallel processing, so that data processing time can be shortened. Private cloud, as an alternative solution to provide cloud services to organizations that are on the same network. The service provided is Infrastructure as a Service (IaaS), where users can request certain types of services and use certain operating systems.

Universities have many computers in the laboratory that have considerable resources if they are able to optimize the use of each computer as a processing resource. Supported by high specification on each computer, it is suitable for private cloud implementation. Using the Openstack framework can produce a good enough performance to perform parallel data processing. The test results show that the parallel processing performance works as expected.

Index Terms—Computer Resources; IaaS; Openstack; Private Cloud.

I. INTRODUCTION

The development of applications is very fast along with the development of computing technology. Distributed applications and parallel processing require large computer resources. Cloud computing is a system that combines several computers into a unified system with the availability of more processor and memory [1]. Although the technology is up-to-date, according to IBM Research Report, CPU usage at various Data Centers is very low, ranging from 7% to 25% with an average of 18%. This means that computers in various Data Centers use more processor specifications to perform activities on the Data Center [2].

At the university, computers with the latest specifications are also not utilized optimally, so that with the cloud computing computer resources can be used to perform parallel processing. The openstack framework as an alternative to cloud computing is an excellent tool to test computer performance simultaneously[3-4].

II. THEORY

Cloud computing is a computational model for enabling scattered, convenient, and on-demand computer network access to share configurable computer resources, such as networks, servers, storage, applications, and services [5]. Cloud computing has 3 service models offered: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a

Service (IaaS) [4]. Computers on the same network can perform parallel processing using the openstack framework and Openstack provides Infrastructure as a Service (IaaS).

A. Openstack

OpenStack is a cloud system software platform that acts as a middleware. Middleware is a software layer that provides programming abstraction, and combines the various layers below, such as networks, hardware, operating systems and programming languages [6]. This means that OpenStack is a service that provides hardware capabilities and is part of Infrastructure as a Service (IaaS). OpenStack consists of various components that communicate with each other to provide services to users. These components include:

- Network Time Service provides the date and time for each node that is in the system.
- Databases are used to store data during operations because most OpenStack services require databases to store information.
- Message Queue Server (RabbitMQ) is a messaging broker, an intermediary for messaging. RabbitMQ provides a common platform for sending and receiving messages and securing messages until messages are received.
- Identity service provides authentication and gives the client node a token that allows access to OpenStack cloud services.
- Image service provides discovery, registration and delivery services for disk images and server images.
- Scheduler (compute management) functions to select computing resources, ie computers that act as compute nodes.
- Dashboard is a Web application used for OpenStack cloud system administration.
- API services are used by applications running in OpenStack systems. The API services provided also include APIs belonging to other nodes.
- Hypervisor or Virtual Machine Manager is a software, firmware, or hardware that works to create and run Virtual Machine. For Hypervisors, libvirt is a driver for Hypervisor that allows live migration from one node to another node.
- Nova-compute, which is the main part that runs the operation.
- Cinder Block Storage stores all data used by the virtual machine.

B. Identity Service / Keystone

Keystone provides identity service and access policy services to all components in OpenStack. Keystone implements REST-based APIs as identity.

Keystone provides authentication and authorization for all

OpenStack components. Authentication verifies that the actual request is coming from the correct source, there are two authentication methods that are username / password based and Token based. Authorization verifies user permissions to the requested service [7].

The components inside the Keystone consist of tenant, service endpoint, region, user and role [7]. Here is an explanation of these components:

- Endpoints.

Each service on OpenStack has a URL (host) and on a dedicated port. The URL and port are called Endpoints.

- Regions.

Region defines the physical location within a data center. In a cloud setting, most services are generally scattered throughout the data center or server, also called the region.

- User.

An account authenticated by Keystone.

- Services.

All services connected with keystone are keystone service. For example, glance (image service) is a keystone service.

- Role

Roles restrict user access within the cloud infrastructure.

- Tenant.

Tenant is a project with all the services, endpoints and users on the tenant.

C. Openstack System

Registered users can access the IaaS feature provided by the cloud system through the user interface of the website. Users can request a virtual machine by selecting a flavor (specs such as CPU, RAM and disk capacity) and image (operating system) [8].

The controller node, where the website is located, will perform the scheduling, which selects the IP address for the virtual machine and compute nodes that meet the criteria according to the capacity requested by the cloud user. At this stage various Openstack services will work together to check user rights over hardware, image, network and storage before running an instance (virtual machine).

A number of instances that run will be on a virtual network that is formed on the host where the virtual machine is operating. It is as if the number of instances is a set of nodes in a cluster.

The user already has a virtual environment created from a collection of virtual machines. Each virtual network formed is connected to the network bridge on the host's physical interface so that it can connect to the network outside the virtual network, in this case the private network belonging to Petra Christian University.

The user as the instance owner must access the instance through the console interface provided on the website only at the first instance of the instance. This step is the stage where the cloud users do the initial setup of the operating system and also the installation of other programs if desired.

Users can enable connections on certain ports according to the security group, a type of OpenStack's firewall. Furthermore, it can be done direct connection to the instance without going through the web interface. The openstack design scheme can be seen in Fig. 1.

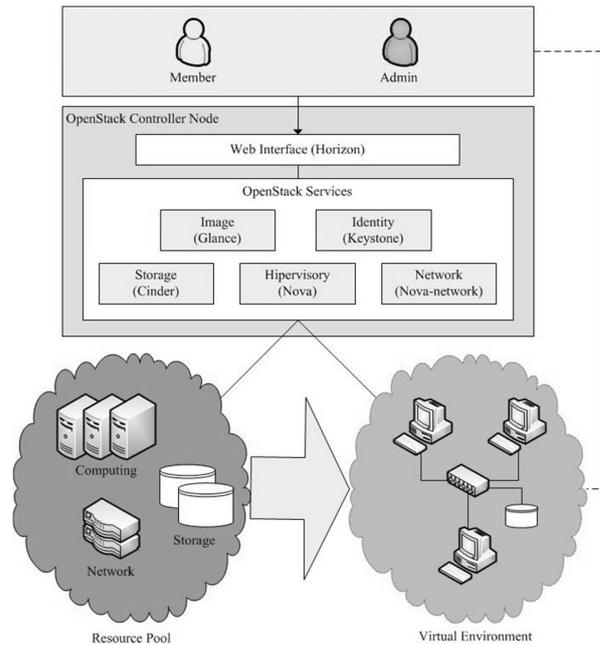


Figure 1: Openstack Schema

III. SYSTEM DESIGN

OpenStack requires 2 networks: Management Network and Public Network. Management Network are used to provide a line of communication systems and cloud administration. Public Network provides access from cloud users, in case of private cloud, this network is a private network (or also called Flat Network). Flat network use the available arrangement which is a private network (192.168.32.0/248). The network will then be shared, 172.16.1.0/24 into a management network and partly for use on a virtual machine that will operate on a cloud system, is 172.16.0.0/24. The network design can be seen in Fig. 2.

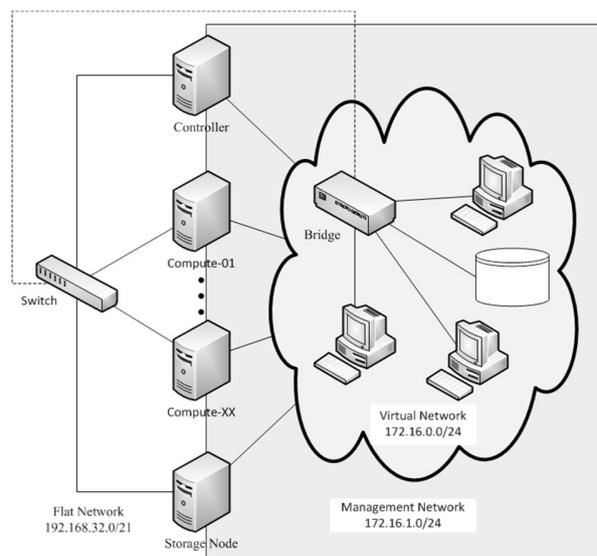


Figure 2. Design Network

A. Basic Environment

Basic environment needed to build openstack system are nodes with operating system Ubuntu Server 14.04 LTS. For each node, the hardware specification is as follows:

- Processor: Intel Core i5-3340 @ 3.1 GHz
(2 cores / 4 threads)
- RAM: 16 GB
- Disk: 250 GB
- Connection: 1 interface 100Mbps Ethernet

In addition, the installation process of the basic components required by Openstack. The basic components are as follows:

- OpenStack Packages

For OpenStack packages installation, Juno cloud repository should be added to the source-list of Advanced Package Tool (APT). APT on each node must update and dist upgrade.

- MariaDB

The Database Management System (DBMS) is mandatory because it is used to store information for every service running on OpenStack. The DBMS installation is performed on the node controller. MariaDB is an open source DBMS that is suggested in making the cloud using OpenStack since the Juno version.

MariaDB has many performance optimizations compared to MySQL in performing simple query execution. So MariaDB is able to handle more SQL commands in units of time.

- RabbitMQ

RabbitMQ is a message broker who receives and continues messages. The RabbitMQ installation is performed on the node controller. In RabbitMQ, all components of OpenStack (services) will act as guest. The settings on RabbitMQ are not changed except the guest password.

- Network Time Protocol (NTP)

NTP installation is done to all nodes residing on the private cloud system. However, the role of the node controller differs from that of the other nodes. NTP on the node controller has a function to provide timing to all other nodes in a private cloud system. For that, the NTP setting on the node controller, must use itself as the time provider and answer the NTP request from another node.

On nodes other than the controller, NTP will be directed to adjust their timing settings to the time provided by the node controller. So that all nodes in the private cloud system have the same time settings as the node controller.

B. Application Framework

The framework used is Juno's OpenStack version, a number of components that operate on OpenStack-based cloud systems. These components are separated into several nodes: a controller node with multiple compute nodes, and additional nodes such as storage nodes and network nodes. Node design can be seen in Fig. 3.

C. Controller Node

Controller Node is the computer in charge of managing the operation of the system as a whole. At this node there are the following components:

- Keystone
- Keystone as Identity service must register service, admin and user who will use system.
- Compute Management

Compute management is a part of the nova compute service located on the node controller.

- Nova-network settings

The settings are performed on the node controller to get to know the legacy network provided by the compute node.

- Horizon

Horizon installation is done after all the main components have been running properly. Horizon is a dashboard used by users to access services provided by private cloud.

- Cinder API

Cinder as additional installation needed to provide service volume. This service is required by virtual machine to have storage media so that each data in accordance with the wishes of the user.

Installation done on the node controller is just the API of the cinder. Cinder API is used to divide the work on the use of volume service by all virtual machines on the system.

D. Compute Node

The compute node acts as the host for the virtual machine run by the user. For that, the compute node has a hypervisor, KVM, a most widely used and tested virtual machine manager (VMM) for the OpenStack system.

Another arrangement is made to form the nova-network that assigns the IP address to the virtual machine. The Nova API is located on the node controller so that network and work settings and distribution are not performed on the compute node.

E. Storage Node

Storage node is an additional node that is added as a storage medium used as virtual hard drive in virtual machine. Before the arrangement takes place a partition is required as a storage medium. The partition provided on the each computer is 250 GB, so the partition created is 200 GB by providing the remaining 50 GB for the Ubuntu system including root and swap.

The partition can be shared to the user and serves as a removable disk between virtual machines. For its use, the user needs to take some capacity to be a virtual disk. Then, the virtual disk can be attached to a VM and the user can access the virtual disk via NFS using a VM in the form of a physical disk.

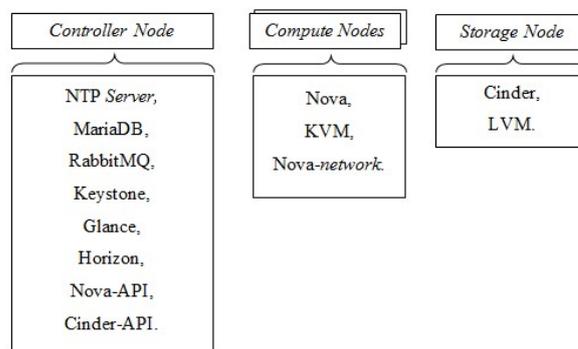


Figure 3. Node Design

F. Virtual Machine Image

The designed private cloud must have an image provided to the user. The image contains the operating system provided by the developer of the operating system and has been verified by

OpenStack as a decent operating system operating as a virtual machine. The selected images are:

- Windows Server 2012 R2 Standard Evaluation Edition
- Ubuntu Server 14.04
- Debian (CLI)
- Windows XP 32-bit

Flavor is a template provided as a virtual machine specification. Flavor includes CPU, RAM and disk capacity. The list of the Flavor can be seen in table 1.

Table 1
List of Flavor

Flavor	CPU Core VCPU	Memory Capacity (GB)	Disc Capacity (GB)
Tiny	1	1	20
Small	1	2	40
Medium	2	4	60
Large	2	8	100
XLarge	4	14	200

IV. SYSTEM IMPLEMENTATION

A. Installation Process

Implementation of openstack Framework using 8 computers, namely: Cont1 as Controller Node, Sto1 as Storage Node. While Cm1, Cm2, Cm3, Cm4, Cm5 and Cm6 as Compute Node.

Each node includes a Node Controller using 2 connected networks, for settings and virtual interfaces. IP Address on the computer using the network configuration in Fig. 2. The IP address of the main interface is 192.168.38.xxx where xxx is the computer number. The IP address of the virtual interface is 172.16.1.xxx where xxx is the computer number.

For each node to recognize another node on the network is to log the IP address into the IP Address-Hostname pair list in the /etc/hosts file for each node.

The openstack installation process is done by following the steps provided by Openstack document. The Openstack installation manual contains a complete guide to the installation process [8].

B. Error Handling

In the implementation process there are problems as follows:
* Nova Service

Nova Service has a dependency on the database (MariaDB). Problems found during Controller Node. Nova services (including nova-cert, nova-consoleauth, nova-scheduler and nova-conductor) are first run by the operating system before the database service is successfully executed. This causes Nova Services to fail and stop. The solution is to change the script at the initializing service by the operating system (Ubuntu 14.04). The location of the script is in the / etc / init / directory. The addition of the script will make Nova Service wait for the database before running the service.

* Cinder Error

Cinder or block storage divides a partition into small parts according to the user and gives it to the user. When the request is submitted to the cinder, the application cannot share the partition and return the error message.

This happens because the app does not have permissions to

change hardware settings. The solution is to provide cinder access as super user, by editing the / etc / sudoers file on Storage Node (Sto1) at the end of the file with the command:

$$\text{Cinder ALL} = (\text{ALL}) \text{NOPASSWD: ALL} \quad (1)$$

C. Add Image File

To get the image, done by downloading the image from the official website or create the image from the installer. Images downloaded through the official website are Windows Server 2012 R2 Standard Evaluation Edition, Ubuntu 14.04 and Debian 8.0 (CLI), while the Windows XP image is created through an ISO Installer.

All images need to be uploaded to the glance to be run by openstack. Here's an example of a command used to upload a Windows XP image.

```
$ glance image-create --name "Windows XP" \
--file wxp.qcow2 \
--disk-format qcow2 --container-format bare \
--is-public True --progress
```

D. System Result

Testing based on the base cache functionality that occurs on the system, Nodes that have cache for base image, need spawning time between 5 to 10 seconds, while for nodes that do not have cache takes time depending on the size of the image used. The time required to run each image without using the cache can be seen in table 2.

Table 2
Image, Size and Spawning Time without Cache

Image name	Size (MB)	Spawning Time
Cirros-0.3.3-x86_64	13	10 – 15 detik
Ubuntu 14.04 Trusty	251	30 – 40 detik
Debian Jessie 64-bit	447	40 – 60 detik
Windows XP	1.699	2 – 3 menit
Windows Server 2012	16.780	25 – 30 menit

The placement of the instance (Virtual Machine) can form several host sharing scenarios. The test will use only 2 scenarios:

- An instance in a host
- Multiple instances in a host

Using these two scenarios, testing is done by calculating the time required by the system to run an instance until the operating system runs. Test results can be seen in Table 3.

Table 3
Test Result from Multiple Instances

Image	Scenario 1 (s)	Scenario 2	
		Instances	Time (s)
Debian Jessie	31	4	60
Windows XP	30		90
Ubuntu 14.04	180		240
Windows Server 2012	720	2	660

Based on table 3 shows that if the host runs multiple instances takes longer time.

The first benchmark uses Sysbench. Sysbench is a benchmark tool and is used to calculate CPU, memory and I / O capabilities.

Testing is done by making an instance closest to a node using the largest flavor (m1.xlarge). Testing aims to determine the ability achieved by an instance compared with the actual host. Therefore, testing is performed against a host and an instance. Test results on CPU, memory and I / O can be seen in Table 4-6.

Table 4
Sysbench Result between Instance and Host (CPU)

Parameter	Instance	Host
Maximum prime number checked in CPU test	20000	20000
Test execution summary		
Total time	7.4611s	6.8509s
Total number of events	10000	10000
Total time taken by event execution	29.8209	27.3939
Per-request statistics:		
Min	2.63ms	2.69ms
Avg	2.98ms	2.74ms
Max	22.76ms	14.76ms
approx. 95 percentile	2.90ms	2.75ms
Threads fairness:		
Events (avg/stddev)	2500.0000/37.93	2500.0000/15.78
Execution time (avg/stddev)	7.4552/0.00	6.8485/0.00

Table 5
Sysbench Result between Instance and Host (Memory)

Parameter	Instance	Host Fisik
Operations performed	1 (149.26 ops/sec)	1 (154.75 ops/sec)
Transferred	32.00 MB (4776.38 MB/sec)	32.00 MB (4952.08 MB/sec)
Test execution summary		
Total time	0.0067s	0.0065s
Total number of events	1	1
Total time taken by event execution	0.0063	0.0062
Per-request statistics:		
Min	6.32ms	6.22ms
Avg	6.32ms	6.22ms
Max	6.32ms	6.22ms
approx. 95 percentile	10000000.00ms	10000000.00ms
Threads fairness:		
Events (avg/stddev)	1.0000/0.00	1.0000/0.00
Execution time (avg/stddev)	0.0063/0.00	0.0062/0.00

Table 6
Sysbench Result between Instance and Host (I/O)

Parameter	Instance	Host Fisik
Operations performed:		
Read	8160	11280
Write	5440	7520
Others	17296	24060
Total	30896	42860
Size:		
Read	127.5Mb	176.25Mb
Write	85Mb	117.5Mb
Total	212.5Mb	293.75Mb
Speed	3.5412Mb/sec	4.8956Mb/sec
Test execution summary		
Total time	60.0076s	60.0032s
Total number of events	13600	18800
Total time taken by event execution	0.0063	0.1187
Per-request statistics		
Min	0.00ms	0.00ms
Avg	0.01ms	0.01ms
Max	0.11ms	0.06ms
approx. 95 percentile	0.02ms	0.01ms
Threads fairness:		

Events (avg/stddev)	13600.0000/0.00	18800.0000/0.00
Execution time (avg/stddev)	0.1235/0.00	0.1187/0.00

The second benchmark uses HPCC. HPCC (High Performance Computer Challenge) is a benchmark software used to measure the performance of a distributed system (cluster). HPCC is another name for LINPACK Benchmark, a benchmark software provided by top500.org that provides high-performance computer related statistics.

Before running the benchmark, the host used should form a cluster. The first step is to make SSH authentication without a password from one host to all other hosts in the cluster. After the cluster is formed, proceed with the HPCC instalasa process and perform the test.

Testing is done by comparing the benchmark results using physical instances and hosts. The results of the measurement and performance comparison between instances and physical hosts generated using HPCC Benchmark can be seen in Table 7.

Table 7
HPCC Benchmark Result

No. Test	# Node	Core/Node	Result (Gflops)		Overhead (%)
			Instance	Host Fisik	
1	1	1	2.7670	2.7830	0.575%
2	1	2	4.6320	4.6600	0.601%
3	2	1	1.5180	1.5340	1.043%
4	1	4	7.6600	7.7780	1.517%
5	2	2	0.9660	1.0320	6.395%
6	4	1	0.8419	0.9171	8.199 %
7	2	4	1.1030	1.1720	5.887 %
8	4	2	0.7225	0.7478	3.383 %
9	8	1	0.7823	0.8512	8.094 %
10	4	4	0.5649	0.5951	5.074 %
11	8	2	0.5596	0.6031	7.212 %
12	8	4	0.5782	0.6130	5.676 %

Based on the data in Table 7, it shows that the performance of an instance / virtual machine is slightly lower against the physical host. On the other hand, each benchmark result using multi-nodes produces a low performance compared to a host. This means that the use of muti-nodes through the network does not improve application performance.

The third benchmark uses Blender. Blender is software for rendering animations and can be used as a cluster render farm. Blender is loose-couple software, which means breaking the animation into several frames separated by its rendering process on many computers.

Testing is done by using animation consisting of 50 frames. The number of nodes used is 5 pieces of virtual machine instance. The configuration uses 1 master node and 4 slave nodes. The results of the tests performed can be seen in Table 8.

Table 8
Test Result using Blender

No. Test	Node Slave	Rendering Time (s)
1	1	5,400
2	2	10,474
3	3	6,566
4	4	4,756

V. CONCLUSION

Implementation of private cloud by utilizing computer resources has satisfactory results in several ways: Good computer network capable of supporting the performance of private cloud though still takes a long time in the delivery of image. Image caching feature can help in solving this problem

Instance on the system is able to achieve performance close to physical host performance, so the CPU capacity can be used optimally.

The disadvantages of this private cloud are on network capabilities that do not support applications such as HPCC. These tight-coupled apps have dramatically reduced performance when run on more than a computer / node.

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