Research and Construction of Antenna Simulation Cloud Computing Platform Based on OpenStack

Pengxue Liu\textsuperscript{a}, Jianxiong Li\textsuperscript{b}\textsuperscript{*}, Chunkai Chen\textsuperscript{c}

School of Electronics and Information Engineering, Tianjin Polytechnic University, Tianjin, China
\textsuperscript{a}liupengxue@126.com, \textsuperscript{b}lijianxiong@tjpu.edu.cn, \textsuperscript{c}chenchunkai@tjpu.edu.cn

Keywords: antenna simulation; cloud computing; elastic resource allocation.

Abstract. Compared with traditional antenna simulation computing, the cloud computing has many remarkable characteristics, such as high efficiency, low level hardware requirements and excellent security performance. Based on OpenStack, an open-source cloud computing platform, we build a platform for the end-users of antenna simulation in universities, pint-sized enterprises and scientific research institutions. It can allocate computing resources flexibly and satisfy consumers according to their requirements such as on-demand use, running smoothly.

Introduction

Most universities, scientific research institutions and pint-sized enterprises who need antenna simulation all face the following dilemma. On the one hand, they have no ability to buy the expensive hardware and software needed by antenna simulation. On the other hand, it will be a waste of material resources and manpower to build the supercomputer for sudden or intermittent antenna simulation calculation.

In order to overcome above difficulties, they can rent antenna simulation platform to complete their tasks. Therefore, it is necessary to combine antenna simulation with cloud computing and build antenna simulation cloud computing platform.

In this paper, we construct a cloud computing platform based on OpenStack \cite{1}. Focusing on customers’ needs, elastic allocation and rapid expansion of resource, network isolation and sharing have been achieved. In addition, the construction scheme of antenna simulation cloud computing platform is elaborated specifically in the paper.

OpenStack Cloud Operating System

The National Institute of Standards and Technology (NIST) gives a more neutral, comprehensive and systematic definition of cloud computing \cite{2}: 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. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models.

OpenStack is a cloud computing platform co-developed by Rackspace and NASA (National Aeronautics and Space Administration), which helps service providers and enterprises implement cloud infrastructure service similar to the Amazon EC2 and S3. At present, OpenStack has received support from more than 200 IT cutting-edge enterprises including Cisco, IBM and HP, etc.

A. Engineering Structure of OpenStack

OpenStack adopts modular design, begins to support the next generation of SDN (Software Defined Network) as one of its components from the Folsom and includes a total of seven major sub projects including Nova, Keystone, Horizon, Glance, Swift, Cinder and Quantum.

1) Nova: utilizing storage, computing, networking and other resources through the virtualization technology (such as Xen, KVM, Esxi VMware, etc.), delivering the computing power to end-users by virtual machine.
2) Keystone: it provides uniform authorization and authentication for all systems in OpenStack.
3) Horizon: it provides a dashboard used by users to interact with other OpenStack services.
4) Glance: it provides the management function of images and directory classification of virtual disk images.
5) Swift: it storages and reads object files by key-value pair.
6) Cinder: managing the block storage and providing the cloud disk service for virtual machine.
7) Quantum: being in charge of virtual machine network resource, including network connection, network mapping, subnet IP, subsequent loading balance, etc.

**Platform Construction**

The deployment scheme of several key parts is described below. Each sub project is deployed in the cluster which is composed of a number of physical hosts, and the major components are constructed according to the HA [3] architecture to achieve high availability of cloud computing platform service.

A. **Deployment of MySQL and RabbitMQ**

The MySQL database and the AMQP (Advanced Message Queuing Protocol) are basic components required by OpenStack. The former is responsible for recording key information and node states produced while system running, and the messaging-passing depends on the latter.

As shown in Fig. 1, in order to ensure the stability of cloud platform, we achieve HA for database and utilize RAID as a pool to store MySQL data information, and meanwhile, mount the memory to multiple MySQL servers through NFS. Heartbeat [4] will be used to forward user-access to the back-end MySQL services through virtual IP.

![MySQL database service based on HA](image1)

**Figure 1.** The diagram of the MySQL database service based on HA.

RabbitMQ [5, 6] is an open source implementation of AMQP, which allows different programming languages and systems to communicate with each other. In this paper, the structure of RabbitMQ is used to realize HA. Once the master node is dead, slave node will be activated to replace it. Fig. 2 is its structure diagram.

![RabbitMQ based on HA](image2)

**Figure 2.** The diagram of the RabbitMQ based on HA.
B. Deployment of KeyStone and Glance

In this paper, Nginx is used as a reverse-proxy server [7, 8] to help Keystone and Glance to achieve HA. Meanwhile, the system with reverse-proxy mechanism realizes the load balancing at back-end. In the case of high concurrency, the user's requests will be balanced to multiple KeyStone and Glance servicers to actualize both load balancing and HA. Its deployment structure is shown in Fig. 3.

![Figure 3. The deployment structure diagram of Keystone and Glance.](image)

C. Deployment of Quantum

We need to install a plug-in named “Open vSwitch” [9] for Quantum, then plan the network cards of physical host to be management network, VM (virtual machine) network and the extranet connecting Internet, respectively.

Quantum provides tenant-oriented API to control the L2 network and manage IP address, it mainly relies on several key daemons that includes quantum-server, quantum-dhcp-agent, quantum-open vswitch-agent and quantum-L3-agent, to work.

Considering the high failure rate of single-point network-access, we achieve HA for network-access, too. We make quantum-L3-agent run on multiple single-points, while monitoring the router L2 external traffic. When router failure occurs, the abnormal state of traffic will be monitored. At this point, quantum-L3-agent will call quantum-server located at the other single-point to create a new router and rebind a new extranet IP to it. As described above, we can eliminate the danger of network paralysis caused by single-point failure. Its deployment structure is shown in Fig. 4.

![Figure 4. The deployment diagram of Quantum.](image)

Cloud Image Production

OpenStack cloud computing platform needs standard VM image file to start an instance. Thus, it is essential to create VM image file and upload it to Glance in advance.

In this paper, the image of the antenna simulation platform is made based on the Windows operating system: firstly install virtio disk driver, then create localized virtual disk space, and install the ISO file to virtual disk via the CD-ROM boot mode according to KVM [10].

Depending on different businesses, we need to produce a variety of image files, and the platform could allow consumers to start corresponding virtual instance in accordance with their actual demands. The planning of cloud image for the antenna simulation is shown in Table 1.
Table 1. Antenna simulation calculation cloud image list.

<table>
<thead>
<tr>
<th>Mirror System</th>
<th>Service Software</th>
<th>Service Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windows 7</td>
<td>HFSS</td>
<td>Finite element method</td>
</tr>
<tr>
<td>Windows 7</td>
<td>CST</td>
<td>Finite-difference time-domain method</td>
</tr>
<tr>
<td>Windows 7</td>
<td>ADS</td>
<td>Moment method</td>
</tr>
</tbody>
</table>

As shown in Table 2, OpenStack has configured different virtual resource types for various businesses, which can maximize the utilization of resources, and verify the advantage of on-demand use for cloud computing. Users can apply for reasonable resource service according to their practical requirements.

Table 2. Virtual host resource allocation list.

<table>
<thead>
<tr>
<th>Virtual Host Type</th>
<th>Resource Allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1.small</td>
<td>1VCPU 512MRAM 10GHD</td>
</tr>
<tr>
<td>M1.medium</td>
<td>1VCPU 1GRAM 20GHD</td>
</tr>
<tr>
<td>M1.large</td>
<td>2VCPU 1GRAM 20GHD</td>
</tr>
<tr>
<td>M1.xlarge</td>
<td>4VCPU 2GRAM 30GHD</td>
</tr>
<tr>
<td>M2.small</td>
<td>1VCPU 2GRAM 40GHD</td>
</tr>
<tr>
<td>M2.medium</td>
<td>2VCPU 2GRAM 40GHD</td>
</tr>
<tr>
<td>M2.large</td>
<td>4VCPU 4GRAM 50GHD</td>
</tr>
<tr>
<td>M2.xlarge</td>
<td>8VCPU 8GRAM 60GHD</td>
</tr>
</tbody>
</table>

Test and Performance Analysis

A. Test Procedure

The test in this paper is based on the LAN because the platform is built in experimental environment. The main processes are listed as following.

1) Enter user name and password, login experimental platform.
2) Create cloud host, select its configuration type according to the business requirements.
3) Create a virtual machine image, choose "Boot from image" in the "Instance Boot Source" column and click “OK” to start the system image associated with the business.
4) Create an external management network and associate the IP with external network, then the system will be automatically assigned to the cloud host a floating IP.
5) Connect the cloud host, remote access can be allowed through the RDP [11] or NoVNC of OpenStack.
6) Users can add the storage block according to business requirements, select virtual block storage with specific capacity to create instance, and mount it to the cloud host by tgt [12].

As shown in Fig. 5, we have created an instance using the HFSS mirror that has been uploaded to Glance. Similarly, users can create more business instances to complete their task.

Also, consumers can open browser and use the required business software to carry out simulation experiment. After testing, the memory usage of software examples in client page is shown in Table 3, which can meet the user experience.

B. Performance Analysis

There are plenty of reasons to build Cloud Computing platform for antenna simulation, such as, lower cost of scientific research, higher utilization efficiency of computing resources and rapid
on-demand services and extensions, etc. Next, the performance of the antenna simulation platform is analyzed from 2 aspects: the cost of software and hardware and the input-output ratio.

![OpenStack](openstack.png)

**Table 3. The client page memory footprint table.**

<table>
<thead>
<tr>
<th>Service Software</th>
<th>Occupied Memory [KB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>HFSS</td>
<td>20444</td>
</tr>
<tr>
<td>CST</td>
<td>37240</td>
</tr>
<tr>
<td>ADS</td>
<td>19472</td>
</tr>
</tbody>
</table>

1) The comparison of software and hardware: after joining the cloud platform, we can avoid the repetitive purchase of hardware equipment and commercial software.

2) Input-output ratio: in this paper, we test one computing node, in which can run 5 virtual hosts, and the utilization of each virtual host can reach 50%~80%. Assuming that the resource utilization rate of physical machine and virtual host is 100%, 50% respectively, we can get the resource utilization ratio as following:

\[
\frac{\text{cloud platform (1 node*5 virtual hosts*50%)}}{\text{1 physical machine*100%}} = 2.5
\]

In fact, the utilization of ordinary physical machine can only reach about 15%, so the input-output ratio of the platform can achieve at least 2.5.

When the computing resources of the cloud computing platform cannot meet current virtual host, new physical machine will be connected to the platform dynamically without adjusting original resources. The expansion of one new physical machine can support the running of 5 or more virtual hosts, input-output ratio is still obvious.

**Conclusion**

This paper describes the basic scheme and the usage method of the antenna simulation cloud computing platform based on OpenStack, aiming at providing the flexible antenna simulation cloud computing service for the small-sized enterprises, scientific research institutions and universities. Through the integration of various antenna simulation softwares in VM mirror, OpenStack can provide different business requirements with an instance environment, in which the hardware resource and system architecture are consistent. After deployment and actual operation, this paper shows the advantages of cloud computing resources, such as high utilization, on-demand use and rapid expansion, which provides an efficient and convenient pattern for antenna simulation.

**Acknowledgment**

This work was supported by the National Natural Science Foundation of China (Grant No. 61372011) and the Tianjin Research Program of Application Foundation and Advanced Technology (Grant No. 15JCYBJC16300).
References


