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Designing and Applying an Education IaaS System based on OpenStack

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Abstract: This paper designs and implements an IaaS (Infrastructure as a Service) system by using OpenStack. To bring deduplication storage of VM images, this paper uses LiveDFS as the file system in image storage backend. And in order to offer stable persistent volumes to VM instances, this paper develops a distributed block-level storage system called ORTHRUS which is integrated into this IaaS system. Additionally, this paper deploys Ganglia monitoring system in the IaaS system to monitor all the physical nodes VM instances. At last, this paper designs and implements a high-performance service, a net disk service and an education management service on this IaaS system.

Keywords: IaaS, block-level storage, deduplication, monitoring system

1. Introduction

IaaS is a basic cloud infrastructure, which provides the basic computational resources to deploy operating systems and applications[1,2]. These resources include cpu, memory and network. The representative products of IaaS are OpenStack[3], Santa Barbara Eucalyptus[4] and Amazon Elastic Compute Cloud [5]. In an IaaS system, block level storage can provide consumers with raw block-level volumes, which can be attached by using remote storage technologies[6] like iSCSI[7,8] and NBD[9]. The most representative block-level storage systems are Eucalyptus, Amazon Elastic Block Store[10,11], and VBS[12].

To design the basic IaaS system, this paper introduces OpenStack, a fully open-source project, which still has the following three main drawbacks: (1) the persistent volume component is not fully distributed which cannot handle well with single-point failures. (2) There is no deduplication function on image storage, which will lead to great pressure when the image data rapidly increase. (3) The monitoring function is not complete which cannot offer all the real-time information of all the physical and virtual nodes.

Therefore, this paper develops ORTHRUS, a fully distributed block-level storage system, which can greatly avoid single-point failures and bring overall system load-balancing. And this paper introduces LiveDFS[13] to bring deduplication storage of image files and save space for image storage backend[14]. And this paper deploys Ganglia monitoring system[15] to the IaaS system to fully monitor all physical and virtual nodes. After these works, this paper implements a basic education IaaS system. On the education IaaS system, this paper develops and implements a high-performance computing service, a net disk service and an education management service.

The rest of the paper will be arranged as following: Chapter 2 is the detailed introduction to OpenStack and Chapter 3 is the description LiveDFS and ORTHRUS. Chapter 4 is about the implementation of the education IaaS system and the services. Chapter 5 is some experiments on the system and services. The last chapter is the conclusion and future work.

2. OpenStack

OpenStack is an open source IaaS projects contributed and developed by NASA and Rackspace. The computing component of OpenStack is originally the Nebula platform[16] which is developed by NASA. And the

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object storage component is originally the Rackspace Cloud Files platform[17,18]. OpenStack consists three main parts: Glance(image service component), Nova (computing component) and Swift(object storage component). The structure of OpenStack is showed in Figure 1.

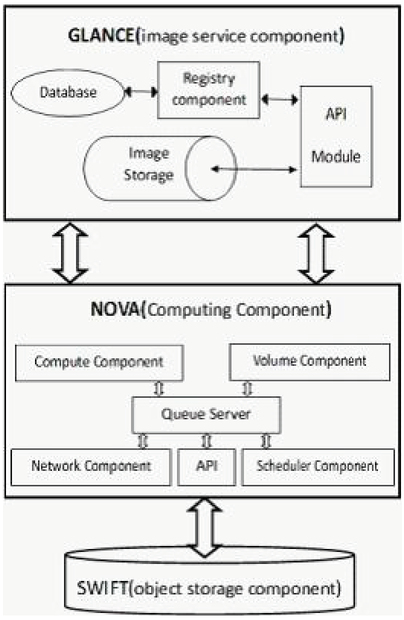

Figure 1 The Architecture of OpenStack.

Designing and deploying the basic IaaS system, we choose OpenStack mainly because of the following two reasons: (1), OpenStack is completely open-source which can be downloaded and utilized by anyone; (2), APIs of OpenStack are compatible with Amazon Web Service, which brings convenient migration from AWS Applications to OpenStack Applications.

3. LiveDFS and ORTHRUS

3.1. LiveDFS

LiveDFS is a file system used for image deduplication storage of open-source cloud platform. It supports POSIX and runs in linux kernel space.

In this paper, LiveDFS is deployed on the image storage backend. And images are stored on LiveDFS. When a consumer wants to launch an instance, cloud controller will get an image from Glance. And Glance retrieves LiveDFS and recovers the image. How LiveDFS is deployed is shown in Figure 2.

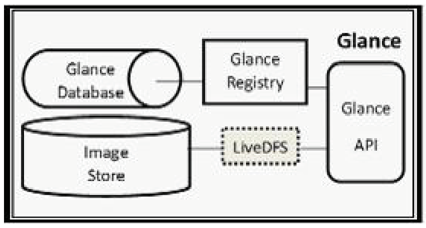

Figure 2 The deployment of LiveDFS.

3.2. ORTHRUS

This paper develops ORTHRUS, a distributed block-level storage system, to strength the block-level storage services of the education IaaS system. ORTHRUS can effectively avoid single point failures because of its distributed architecture. As is shown in figure 3, ORTHRUS mainly consists of four components, which are ORTHRUS client, ORTHRUS servers, volume servers and VMM servers.

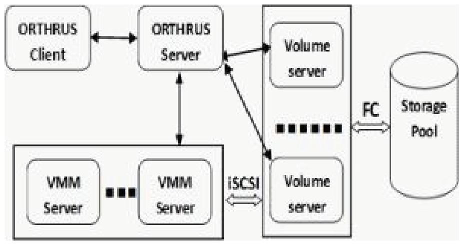

Figure 3 The Architecture of ORTHRUS.

ORTHRUS client is the interface for users to access to the system and provides APIs for applications. And in this paper, these APIs are utilized to combine the ORTHRUS system and the basic IaaS system. Volumes servers, which are connected to the storage pool, manage the volumes of all the storage system. VMM Server supplies virtual machines. In this paper, the compute nodes of the basic IaaS system are VMM servers. And volumes from Volume Servers are attached to the VMs by iSCSI protocol. ORTHRUS Server is the main management component which handles the requests and coordinates with other components. Compared to OpenStack Volume component and other block storage systems, ORTHRUS has two advantages: (1), the ORTHRUS Server cluster and the Volume Server cluster brings great stability and can avoid single point failures; (2), to avoid the performance bottleneck by the unbalance among servers, load-balancing strategy are utilized by ORTHRUS. Therefore, ORTHRUS can effectively and stably brings volumes services to the virtual machines of the underlying IaaS system.

4. Designing and Implementation of the IaaS education system

4.1. Physical Deployment

To deploy the IaaS system, this paper uses 17 physical nodes and one disk array. And the nodes includes 2 Dell OPTIPLEX 980 PCs, 2 Dell R710 servers and 13 Dawning A620r-G servers. And the volume of the disk array is 10T. And the detailed equipment parameters are showed in Table 1.

Table 1 Parameters of equipments.

	Quantity	CPU	Memory	Network	OS
Nova Compute main node	1	AMD OPTERON O56136	32GB	1000m/s	Ubuntu 11.10 3.0.0.11-generic
Nova Compute node	8	AMD OPTERON O56136	32GB	1000m/s	Ubuntu 11.10 3.0.0.11-generic
Swift node	3	AMD OPTERON O56136	32GB	1000m/s	Ubuntu 11.10 3.0.0.11-generic
Nova Volume node	1	AMD OPTERON O56136	32GB	1000m/s	Ubuntu 11.10 3.0.0.11-generic
Volume server node	2	Intel Xeon 2.13GHz CPU*8	8GB	1000m/s	CentOS 5.4 2.6.18.238
ORTHRUS Server node	1	Intel Core 2.98GHz CPU*4	2GB	1000m/s	CentOS 5.4 2.6.18.238
ORTHRUS server client	1	Intel Core 2.98GHz CPU*4	2GB	1000m/s	CentOS 5.4 2.6.18.238

As is shown in table 1, 9 Dawning servers are used to deploy computing component. One Dawing server is deployed with volume component. 3 Dawning nodes are deployed with swift component. 2 Dell servers and 2 Dell pcs are used to deploy ORTHRUS system. And ORTHRUS Client is the interface to computing nodes. And additionally the LiveDFS is deployed in the main computing node as the Glance component.

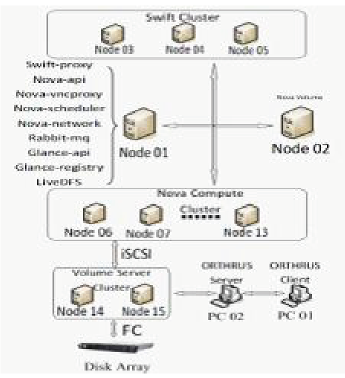

Figure 4 Deployment of the IaaS system.

4.2. Ganglia Monitoring System

This paper uses Ganglia as the monitoring system to strength the monitoring function of the underlying IaaS system. And the main node, node 01, deploys the Gmetad daemon component and the web frontend component to collect the overall live information and show them to the users. And the rest physical and virtual nodes deploy Gmond daemons to collect live information of each node.

4.3. Service Development

In this paper, storage and VM resources offered by the IaaS system are used to develop three educational services: a high-performance computing service, a net disk service and an education management service.

(1) High-Performance Computing Service

In order to deploy the high performance service, this paper makes a VM template with several popular parallel computing softwares, including FORTRAN, MPI and OpenMP. When users need to run their parallel programs, they can make use of this template to generate as many VMs as they want to build parallel computing clusters.

To test the high performance computing service, this paper choose a parallel program for three-dimensional incompressible pipe flow based on SIMPLE[19]. And the details will be discussed in the fourth section.

(2) Net Disk Service

A two-level infrastructure is designed for the net disk service. The storage level uses GlusterFS to manage underlying storage resources and offers on-demand storage to upper level servers. And the service level consists two components, including several web servers and a database server. And the service level collects storage resources and offers them to users by web browsers. And each user can apply a 10G net disk.

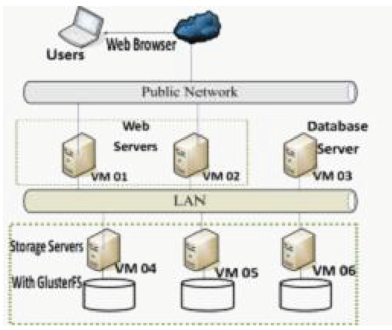

Figure 5 Deployment of Net Disk Service.

As is shown in Figure 5, VM 01 and VM 02 are the web servers. And VM 03 is the database server. And VM 04-06 are storage servers deployed with GlusterFS.

(3) Education Management Service

To deploy education management service, this paper makes a virtual machine with windows server 2003 operating system with 8 cpus, a 500G disk and a 16G memory. This paper uses C# and SQL Server 2005 to design the education website. And this platform offers users file sharing service, information sharing service and so on. Teachers and students can upload their important files for all the users and exchange important education information.

5. Experiments and A Case Study

5.1. ORTHRUS Performance

This paper designs an experiment for ORTHRUS system to test the performance of the volume generated by ORTHRUS. A VM is launched which has a centos 5.4 operating system, one cpu, one 512M memory and a 10G ORTHRUS volume. And this paper chooses ext2 as the file system on the volume. And this paper uses Iometer tool to test all kinds of the volume performance. And the detailed results are showed in Figure 6.

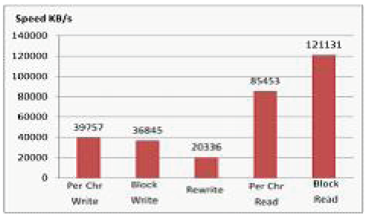

Figure 6 The Performance of ORTHRUS Volume.

5.2. Testing on LiveDFS

In this paper, we test the LiveDFS on dedupulication storage of VM images. We choose three kinds of images which are centos, ubuntu and Windows XP. We test the space of the single image file and multiple image files stored on LiveDFS in Glance Image store backend. The details of the experiments are shown in Table 2. As is shown in the experiments, LiveDFS contributes greatly to the deduplication storage of image files. Firstly, for a single image file, LiveDFS saves about 27.3% to 94.6% of space (27.3% for a Windows XP file, 78.8% for a centos file, and 94.6% for an ubuntu file). This is mainly because of numerous zero blocks in these image files. These zero blocks are generated due to the unused space of the image file. Secondly, among multiple image files of the same type, LiveDFS only occupies space for one single file. At last, among different image files, LiveDFS can save more space.

Table 2 Parameters and Experiments on LiveDFS.

Operating System type	kernel	Number	Original Size	Experimental result
Centos 5.4	2.6.18	1	10GB	2.2G
Centos 5.4	2.6.18	2	30GB	2.2G
Ubuntu 11.10 desk	3.0.0.11-generic	1	10GB	654M
Ubuntu 11.10 desk	3.0.0.11-generic	3	30GB	654M
Windows XP		1	2.2GB	1.6G
Windows XP		3	6.6GB	1.6G
Centos Ubuntu 11.10 desk Windows XP	2.6.18 3.0.0.11-generic	3 3 3	66.6GB	4.1G

5.3. A case study on high-performance computing service

A case study on the high performance computing service is showed in this paper. And this paper uses a program for 3-dimensional incompressible pipe flow based on SIMPLE as the case. And SIMPLE is short for Semi-Implicit Method for Pressure Linked Equations and is used in simulation of steady flows[20]. And this paper uses 8 VMs offered by the underlying IaaS system. And each of VMs has 4 cpus, a 4G memory, a 10G disk and centos 5.5 operating system. And the GCC version is 4.1.2. And the result is showed in Figure 7.

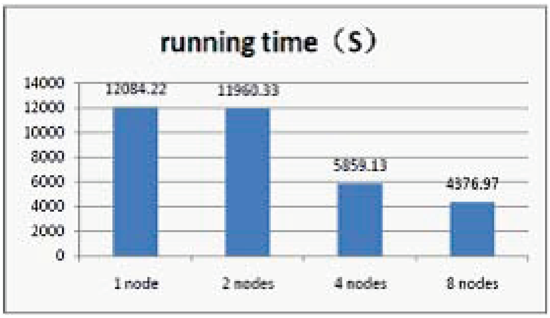

Figure 7 The running time of the program.

6. Conclusion and future work

Based on OpenStack, this paper designs and implements an IaaS system with deduplication storage of VM images and scalable block-level storage. And this paper designs and implements a high-performance computing service, a net disk service and an education management service on this IaaS system. And in the future, this paper will develop and strength the IaaS education system by doing the following works: (1), this paper will study the VM migration strategy and add related component to balance the overall load of the IaaS system; (2), this paper will develop more useful applications and services for teachers and students.

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