Private Cloud Cooperation Framework for Reducing the Earthquake Damage on e-Learning Environment

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Abstract. In this research, we have built a framework of reducing earthquake and tsunami disaster for e-Learning environment. We build a prototype system based on IaaS architecture, and this prototype system is constructed by several private cloud fabrics. The distributed storage system builds on each private cloud fabric; that is handled almost like same block device such as one large file system. For LMS to work, we need to boot virtual machines. The virtual machines are booted from the virtual disk images that are stored into the distributed storage system. The distributed storage system will be able to keep running as one large file system when some private cloud fabric does not work by any troubles. We think that our inter-cloud framework can continue working for e-Learning environment under the post-disaster situation.

Keywords: e-Learning environment, inter-cloud framework, disaster reducing.

1 Introduction

On March 11, 2011, a major earthquake attacked to Eastern Japan. Especially, the east coast of Eastern Japan was severely damaged by the tsunami attacking. In Shikoku area including our universities in Tokushima prefecture, it is predicted that Nankai earthquake will happen in the near future. It is expected to have Nankai earthquake in the next 30 years, and its occurrence rate is between 70 percent and 80 percent. We have to prepare for the major earthquake. It will be like Eastern Japan Great Earthquake that the damage caused by earthquake and tsunami was heavy. It is very important disaster control, and it is same situation for information system's field.

On the other hand, the informatization of education environment on universities is rapidly progressed by evolutional information technology. Current education environment cannot be realized without education assistance system, such as LMS, learning ePortfolio, teaching ePortfolio and so on. The learning history of students is stored these education assistance system. The fact is that awareness of the importance of learning data such as learning histories and teaching histories. The assistance systems are important same as learning data. In addition, an integrated authentication

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framework of inter-organization is used to share the course materials. For example, Shibboleth Federations is used to authenticate other organization's user for sharing the course materials within consortium of universities. Today's universities educational activity cannot continue smoothly without those learning data and assistance system. If the data and assistance systems lost by disasters, it is difficult to continue educational activity.

We can find applications for constructing information system infrastructure by the private cloud technology for universities. Generally, those application examples are based on a server machine virtualization technology such as IaaS (Infrastructure as a Service). For example, we can find Hokkaido University Academic Cloud [1]. One of the aims of this system is to provide a lot of Virtual Machines (VMs) which are kitted out with the processing ability of huge multiple requests by VMs administrator. The VMs administrator can get constructed VM with an administrator authority. It is server hosting service with adaptive configuration for VM's administrator. Other case is to provide huge resources for distributed data processing infrastructure such as Hadoop framework [2]. Their aims are to provide effective use of computer hardware resources, and providing a centralized control of computer hardware resources. It is different purpose for disaster prevention and the reduction of damage in earthquake situation.

Nishimura's study [3] provides a remote data backup technology for distributed data keeping on multiple organizations such as universities. This study is considered migration transparency of distributed backup data using a storage virtualization technology. This system guarantees a security of the backup data, and transparency by Secret Sharing Scheme. However, the main target of this architecture is the data backup and keeping its transparency. Therefore, it is not designed to continue users request handling with user data.

In this research, we have built a framework of reducing earthquake and tsunami disaster for e-Learning environment. We build private cloud computing environment based on IaaS technology. This private cloud environment is constructed from any private cloud fabric with the distributed storage system into several organizations. The Learning Management Systems such as Moodle build on several private cloud fabrics. Each VM has a LMS and the related data. General IaaS platform such as Kernel-based Virtual Machine (KVM) [4], Xen [5] and VMware vSphere [6] has a live-migration function with network shared storage. General network shared storage is constructed by iSCSI, NFS and usual network attached storage (NAS) system. Unfortunately, these network shared storage systems are bound to any physical storages on the each organizations. As a result, it is difficult to do the live-migration of VMs between inter-organizations such as universities.

Our prototype platform is built with distributed storage system and KVM based IaaS architecture on a lot of usual server hardware with network interfaces. It is able to handle many VMs including LMS and the data with enough redundancy. And, this prototype platform will operate on the inter-organizations. As a result, our prototype platform will be able to integrative operate each organization's private cloud fabric. If one organization's e-Learning environment is lost by some disaster, it will be able to keep running same environment on other organizations environment. When the rebuild an infrastructure on the damaged organization, lost environment will be able to reconstruct by other organizations environment. Therefore, we think that the damaged organization can keep running e-Learning systems, and does not lose data such as learning history.

In this paper, we propose the inter-cloud cooperation framework between private cloud fabrics on several organizations, and we show a configuration of the prototype system. Next, we show the results of experimental use and examine these results. Finally, we describe future study, and we show conclusions.

2 Assisting the Disaster Reduction for e-Learning Environment

In this section, we describe the inter-cloud cooperation framework of e-Learning environment. Especially, the purpose of this framework is a disaster reduction for LMS such as Moodle, and to keep running LMS and related data.

Fig.1 shows a framework of disaster reduction assistance for the e-Learning environment. Each organization such as university has a private cloud fabric, it is constructed a lot of server hardware and network connections between many server hardware. Each server hardware does not independent other server hardware on the private cloud fabric. They provide computing resources and data store resources via VMs, their resources are changed adaptively by the request from the administrators. Each VM which exists on the private cloud fabric is generated from the resources in the private cloud fabric, it is able to process any function such as authentication, and LMS function on the VM. In addition, Each VM can migrate between other private cloud fabrics, and it is able to continue to keep processing.

A live migration function needs a shared file system to do the VM's migration. The product of Sheepdog Project [7] is applied to our framework. Sheepdog is a distributed storage system optimized to QEMU and KVM hypervisor. Our proposed framework builds by KVM hypervisor, and Sheepdog distributed storage system provides highly available block level storage volumes. It can be attached to QEMU based VMs, it can be used to boot disk image for the VMs. Sheepdog cluster does not have controller or meta-data servers such as any SAN storage or GlusterFS [8]. The controller and meta-data servers could be a single point of failure under the disaster situation. We will lose all VM's image and all any history data when we lost meta-data servers. Therefore, we cannot take the distributed storage solution such as meta-data server model. The distributed storage system which is based on Sheepdog product does not have the single point of failure. Because, Sheepdog has a fully symmetric architecture, this architecture does not have central node such as a meta-data server. If some server hardware which compose Sheepdog cluster, it has small risk to lost the VM image file and history data. In addition, we think each VM image is able to find other organization's private cloud fabric. Because, Sheepdog based distributed storage system is constructed integrally on the several organization's private cloud fabrics. It can be able to reboot the VMs on other organization's private fabric under the disaster situation. Where possible, the VMs which are running on the several organizations move to riskless other private cloud fabric, and keep running the VMs.

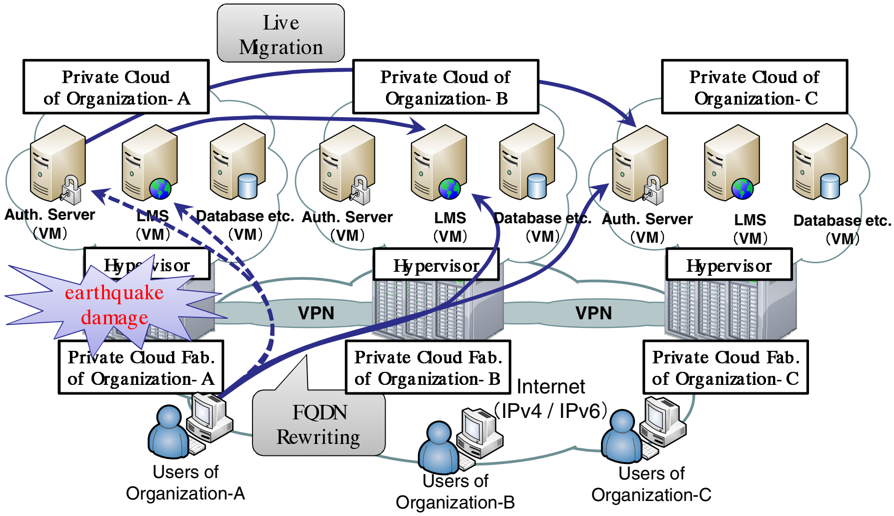

Fig. 1. Framework of disaster reduction assistance for the e-Learning environment

However, if VMs migrate between several private cloud fabrics in working condition, it is not true that each organization's users can use several services. The hostname which is used to access the services, it must be rewrite to the previous organization's FQDN (Fully Qualified Domain Name). Generally, the users of organization-A want to access own LMS, they use the FQDN of organization-A. When the VM of organization-A is under controlled by the private cloud fabric of organization-B, that VM's FQDN has to provide the hostname related to organization-A. This function must operate at the same time as the live migration function.

As a result, we think we can assist to provide this inter-cloud framework against the disasters for e-Learning environment.

3 System Configuration

We show the configuration of proposed system in Fig.2. This is a prototype configuration of proposed framework.

This system has three components and two internal networks. The first one of the components is the server hardware cluster. This is a core component of our prototype system. They are constructed by eight server hardware as shown by node1 to node8. This server hardware is based on Intel architecture and three network interfaces. Each server has the function of KVM hypervisor, virtualization API and Sheepdog distributed storage API. Each server can be used for the VM execution infrastructure, and it is also to use the composing element of Sheepdog distributed storage system. As a result, it is realized sharing the hardware to use VM executing infrastructure, and it is implemented a reliability and a scalability of the storage.

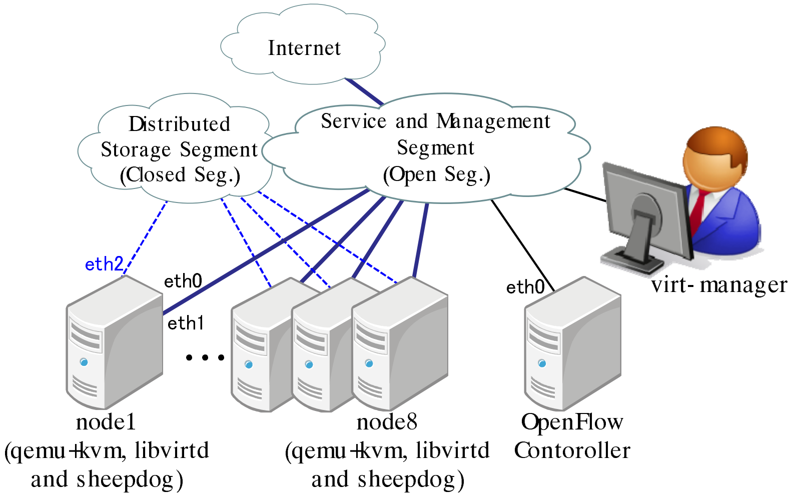

Fig. 2. System configuration of prototype system

The second one of the components is a Software Defined Network (SDN) controller based on OpenFlow [9] architecture. These servers which compose the VM execution infrastructure have the function of OpenFlow switch based on Open vSwitch [10]. This function is used for making optimum path, and it is also used for integrating several distributed storage.

The third one of the components is the Virtual Machine Manager [11]. This function is used for management several VMs by VM's administrator on this prototype system. In addition, any alert system of earthquake will control VMs live migration and saving the learning history via virt-manager interface on this prototype system.

On the other hands, our prototype system has two internal networks. The one of the internal network is provided to make closed segment, it is used to make a keep-alive communication, and making the storage data transfer between Sheepdog distributed storage clusters. The second of the internal network provides network reachability to the Internet, and it provides the connectivity between the users and LMS services. In addition, this network segment is used to make a connection for VM controls under the secure environment with optimized packet filtering.

4 Experimental Use and Results

This prototype system was tested to confirm its effectiveness. We made the virtual disk images and virtual machines configuration on our prototype system. And, several VMs was installed LMS such as Moodle. Each size of the virtual disk image is about 20GB on this experimental use.

Table 1 presents the server hardware specification for the distributed storage system's cluster, and the OpenFlow controller specification is presented in Table 2.

Table 1. Specification of the server cluster

CPU	AMD Opteron 3250 HE (Quad Core)
System Memory Capacity	16.0Gbytes
HDD Capacity	250Gbytes with SATA600 interface
Operating System	Ubuntu Server 12.04 LTS 64bit ed.

Table 2. Specification of OpenFlow controller

CPU	Intel Xeon E3-1230 3.2GHz (Quad Core)
System Memory Capacity	16.0Gbytes
HDD Capacity	250Gbytes with SATA600 interface
Operating System	Ubuntu Server 12.04 LTS 64bit ed.

The prototype of the distributed storage system is constructed by eight servers, and each server has 250Gbytes capacity HDD. The total amount of physical HDD capacity is about 2.0Tbytes. Each clustered server uses about 4Gbytes capacities for the hypervisor function with an operating system. We think this amount is ignorable small capacity. However, the distributed storage system has triple redundancy for this test. As a result, we can use about 700Mbytes storage capacity with enough redundancy. The total capacity of the distributed storage system can extend to add other node servers, exchange to larger HDDs, and taking both solutions. We can take enough scalability and redundancy by this distributed storage system.

We tried a live-migration the VMs from the node1 to node2. We show the screen capture in Fig.3 of the test. We used to operate VM's live-migration by the interface of Virtual Machine Manager. The time of live-migration is needed about 10 to 15 seconds on this test. We think it is enough live-migration time for a disaster reduction of provided VMs. And, we could get a complete successful result with active condition.

However, the live-migration of this experimental use is operated by my hands. Naturally, we think we have to make an operation of VMs live-migration automatically. The problem of this future work is how it can be make a trigger of this migration. We think we will use a vibratory sensor via serial communication interface or USB interface. But, we think this method have a lot of false detection situation. For example, when someone touches or moves the vibratory sensor, the false detection is kicked up by these faults. In addition, it is difficult to keep similar level of each organization's sensing capability. Each sensor device has definitely a variation of sensing capability.

We think we will use an emergency notification of the disaster from any mobile communication carrier such as NTT DoCoMo, KDDI and Softbank via their smart phones. The custom application program is installed to any smart phone such as Android platform and iPhone platform. If we can get the information of emergency notifications via smart phone with near field communication method such as USB interface, Bluetooth communication method and so on, we will be able to make a trigger of VMs live-migration with more precision.

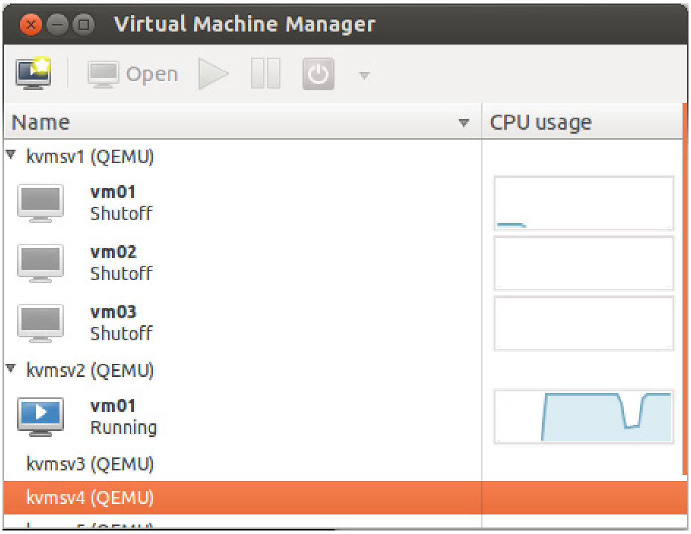

Fig. 3. Live-migration result by Virtual Machine Manager

The results of this experimental use are pretty good. The time requirement for VMs migrating was a short period. However, the results were getting under the initial conditions. The VMs which are installed Moodle system were quite new condition. Generally, when the VMs are operated to continue long period, each VM has large history data. Therefore, the time of live-migration will need more than initial condition. We think we have to make the experimental use under the actual conditions.

5 Conclusion

In this paper, we proposed a framework of disaster reduction for e-Learning environment. Especially, we described an assistance to use our proposed framework, and we show the importance of an against the earthquake and tsunami disaster for e-Learning environment. We built the prototype system based on our proposed framework, and we described a system configuration of the prototype system. And, we shown the results of experimental use and examine.

For the future, we have a plan to implement the function of getting earthquake notifications from any smart phone. And we will try to test the cloud computing orchestration framework such as OpenStack and CloudStack. And, we will try to experiment confirming its effectiveness under the inter-organization environment.

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