BUILDING OF A DISASTER RECOVERY FRAMEWORK FOR E-LEARNING ENVIRONMENT USING PRIVATE CLOUD COLLABORATION

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ABSTRACT

In this research, we have built a framework of disaster recovery such as against earthquake, tsunami disaster and a heavy floods for e-Learning environment. Especially, our proposed framework is based on private cloud collaboration. We build a prototype system based on IaaS architecture, and this prototype system is constructed by several private cloud fabrics. These private cloud fabrics are operated as a large private cloud fabric. The distributed storage system builds on each private cloud fabric; that is handled almost like same block device. For LMS (Learning Management System) to work, we need to boot up virtual machines which installed LMS. The virtual disk images of each virtual machines are stored into the distributed storage system. The distributed storage system will be able to keep running as a large file system. We can control the virtual machines' status and virtual machines positioning on the private cloud fabrics by the private cloud collaboration controller with a smartphone communication. The private cloud collaboration controller is able to grasp disaster alert notifications. The disaster alert notification can be caught by a cellphone carrier via smartphone function. We think that our private cloud collaboration framework can continue working for e-Learning environment under the post-disaster situation. In this paper, we show our private cloud collaboration framework. And next, we show the experimental results on the prototype configuration.

KEYWORDS

Disaster Recovery, e-Learning Environment, Private Cloud Collaboration, Disaster Alert Notification

1. INTRODUCTION

On March 11, 2011, a major earthquake attacked to Eastern Japan. Especially, the east coast of Eastern Japan had severely damaged by the tsunami attacking. In Shikoku area including our universities in Western Japan, it is predicted that Nankai earthquake will happen in the near future. There is an interval theory that Nankai earthquake occurs every 100 to 150 years on the Pacific side in Western Japan. It is expected to have Nankai earthquake in the next 30 years, and its occurrence rate is between 70% and 80%. We have to prepare the disaster for the major earthquake.

In addition, we have a lot of experience which is the record rainfall in a short period last few years. There are not uncommon story which the huge flood is caused by a short period rainfall. Especially, we had a heavy record rainfall and heavy floods, it attacked to Western Japan area at August 2014. We had heavy damage by these disaster. It is no longer special for us to suffer from disasters very often. We think the preparing for the disaster is very important for keeping our life, also it is very important for the information system's field.

On the other hand, the informatization of educational environment on universities is rapidly progressed by evolutional information technology in Japan. Current educational environment cannot be realized without educational assistance system, such as LMS (Learning Management System), learning/teaching ePortfolio and so on. The learning history of students is stored by these educational 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. Today's educational environment on universities depends on educational assistance system with information technology infrastructure. If the educational assistance system including students learning history is lost by these disasters, we think it become equivalent to lost sustainability for educational activity.

In addition, an integrated authentication framework of inter-organization is used to share the course materials. For example, Shibboleth Federations such as GakuNin [1] 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.

We can find applications for constructing information system infrastructure by the private cloud technology for academic field such as Yokoyama's study [2]. The target of these study is to provide massively parallel computing such as Apache Hadoop environment [3]. 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 recovery and the reduction of damage by large-scale disasters.

In this research, we have built a framework of disaster recovery from large-scale disaster such as earthquake and tsunami for e-Learning environment. We build a private cloud computing environment based on IaaS (Infrastructure as a Service) technology, and our target is to build the private cloud collaboration framework. This private cloud environment and private cloud collaboration framework are constructed from any private cloud fabrics with the distributed storage system into several organizations. The Learning Management System such as Moodle [4] build on several private cloud fabrics. Each VM (Virtual Machine) has a LMS and the related data with a SQL database. General IaaS platform such as Linux KVM (Kernel-based Virtual Machine) [5] has a live-migration function with network shared storage and Virtual Machine Manager [6]. General network shared storage is constructed by iSCSI, NFS and usual network attached storage system. These network shared storage systems are bound to any physical storages on the each organizations. Therefore, it is difficult to do the live-migration of VMs between inter-organizations.

Our prototype platform is built with distributed storage system and KVM based IaaS architecture on a lot of usual server machines with network interfaces. It is able to handle many VMs including LMS and the data with enough redundancy. And, this prototype platform will operate inter-organizations. Thus, our prototype platform will be able to operate integrative each organization's private cloud fabric. If one organization's e-Learning environment on the private fabric is lost by some disaster, it will be able to keep running same environment on other organizations environment. In addition, our prototype platform can get emergency earthquake alert by smartphone via cell-phone carrier in Japan. Japanese cell-phone carrier is able to send emergency alert message when major earthquake generated cooperating with Japan Meteorological Agency. Our prototype platform make live-migration function when earthquake alert grasped.

In this paper, we propose a private cloud collaboration framework between private cloud fabrics on several organizations, and we show a configuration of the prototype system. And, we show the results of experimental use and examine these results.

2. ASSISTING THE DISASTER RECOVERY FOR LMS

In this section, we describe the private cloud collaboration framework for e-Learning environment. Especially, the purpose of this framework is a disaster recovery for LMS and to keep running LMS including related data.

Figure 1. shows a proposed framework of disaster recovery assistance for e-Learning environment. Each organization such as university has own private cloud fabric. Own private cloud fabric has several node machines at least four machines to get enough fabric's redundancy. Each node hardware does not independent other node hardware on the same private cloud fabric. The computing resources and the data store resources are provided via VMs, and the resources are changed adaptively by the request from the administrators. The VM can migrate between other private cloud fabrics, and it is able to continue to keep running. A live migration function needs a shared file system to process the VM's live-migration. The distributed storage system supplied by Sheepdog Project [7] does not have meta-data server, it means this distributed storage system does not have single point of failure. Because, this distributed storage model is the pure distribution architecture.

Each private cloud fabric has private cloud collaboration controller. A private cloud collaboration controller is constructed live-migration function with customized smartphone and Libvirt Virtualization Toolkit. Today's general smartphone such as Android has a function which get the earthquake alert notification such as ETWS (Earthquake and Tsunami Warning System) [8].

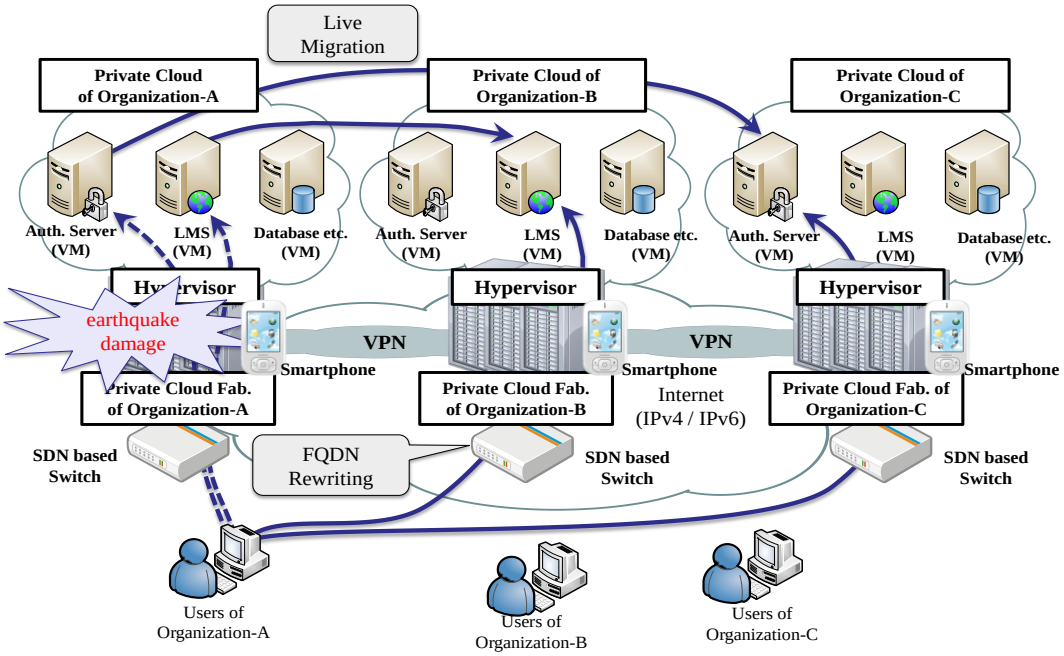

Figure 1. Framework of disaster recovery for e-Learning environment

The private cloud controller which received alert notification makes live-migration command for controlled VMs. We apply IP address rewriting after VMs live-migration function by Software Defined Network based switches, and FQDN (Fully Qualified Domain Name) is rewrote by the private cloud controller triggered this operation. As a result, we think we can assist to provide this inter-cloud framework against the disasters for e-Learning environment.

3. SYSTEM CONFIGURATION

This section describes a system configuration of prototype system which based on our disaster recovery framework. The configuration of prototype system is shown in Figure 2.

This prototype system has four components. The first one of the components is the node cluster for an Infrastructure as a Service function build by multiple node machines. This is a core component of our prototype system. There are constructed by eight node machines as shown node1 to node8. The cluster which is constructed from node1 to node4 is included same private cloud fabric. The other cluster which is constructed from node5 to node8 is included other same private cloud fabric. These private cloud fabrics are placed different organization physically. The node machine which is organized by private cloud fabric is based on usual Intel architecture including three gigabit network interfaces. Each node has the function of KVM hypervisor such as virtualization API and Sheepdog distributed storage API. Each node 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 resources to use VM executing infrastructure, and it is implemented a reliability and a scalability of the storage.

The second component is Layer 2 VPN connection. Layer2 VPN such as EtherIP technology makes connection between both private cloud fabrics. And, the IPsec technology is used to make a secure tunnel connection for Layer2 VPN. As a result, both private cloud fabrics are organized same cluster logically.

The third component is a SDN (Software Defined Network) controller based on OpenFlow architecture [9]. These nodes which compose the VM execution infrastructure have the function of Open Flow switch. This function is used for making optimum path dynamically between several private cloud fabrics.

The fourth component is the private cloud collaboration controller. This cloud collaboration controller has functions, there are catching earthquake alert notification via cell-phone carrier using smartphone function. Then, cloud collaboration controller makes live-migration command for target node machine, and sending

command to the target node machine. And the private cloud collaboration controller has each VMs status on private cloud fabrics, it was caught from Libvirt Virtualization Toolkit and Virtual Machine Manager. When the private cloud collaboration controller makes live-migration command to target VMs, it was planned adaptively based on managed VMs status. As a result, any alert system of earthquake will control VMs live-migration and saving the learning history via Libvirt interface on this prototype system.

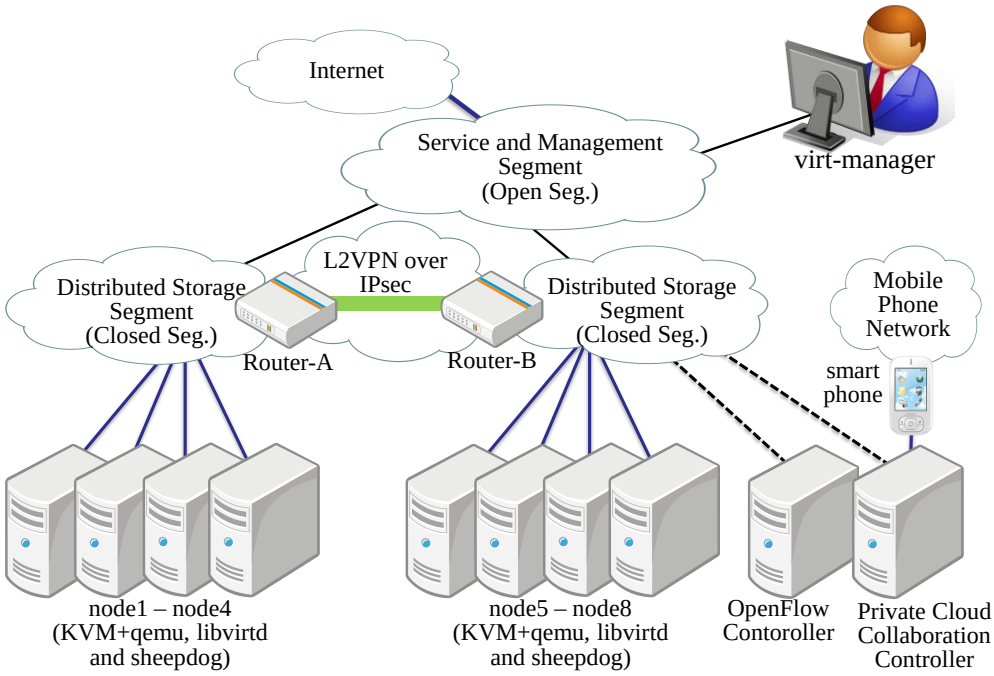

Figure 2. The configuration of prototype system

4. EXPERIMENTAL USE AND RESULTS

This framework system was tested to confirm its effectiveness. We made prototype system for this experimental use. Table 1 shows the specification of the private cloud node machine and the cloud collaboration controller.

Table 1. Specification of the private cloud node machine and the cloud collaboration controller

CPU Specification	AMD Opteron 3250HE (Quad Core)
System Memory Capacity	16.0Gbytes
HDD Capacity	250Gbytes with SATA600 interface
Operating System	Ubuntu Server 14.04.1 LTS 64bit ed.

We made the virtual disk images and virtual machines on the private cloud node machine. And several VMs was installed LMS such as Moodle. Each size of the virtual disk images is 10GB, and each size of allocated VM's memory is 4GB on this experimental use. The prototype of the private cloud fabrics are constructed by eight node machines, and each node hardware has 250Gbytes capacity HDD. The total amount of physical HDD capacity is about 2.0Tbytes. Each clustered node uses about 4Gbytes capacities for the hypervisor function with a base operating system. We think this amount is ignorable small capacity. Because, the distributed storage system have to use triple redundancy function for this test. Therefore, we can use about 700Mbytes storage capacity with enough redundancy. The total capacity of the distributed storage system can extend capacity to add other node machines, or exchange to larger HDDs, and taking both solutions. We can take enough scalability and redundancy by this distributed storage system.

We tried to do a live-migration on our prototype system. We make the test with two cases. One of the case is to do live-migration in the same private cloud fabric. This case is targeted making live-migration in same private cloud fabric. The other one is to do live-migration between private cloud fabrics. This case is targeted making live-migration for inter-cloud situation.

Table 2. Time of live migration

Same private cloud fabric	27.3 sec
Inter private cloud fabrics	28.4 sec

Table 2. shows the time of live-migration for experimental usage. We used the operate VM's live-migration by the interface of Virtual Machine Manager triggered from cloud collaboration controller. The time of live-migration for same private cloud fabric is needed 27.3 seconds. On the other hand, the time of live-migration for inter-private cloud fabrics is needed 28.4 seconds. Each private fabric is connected with Layer2 VPN connection. We think that both experimental result is enough live-migration time for disaster reduction of provided VMs. And, we could get a complete successful result with active condition.

In addition, the live-migration of these experimental use is operated by the cloud collaboration controller, and this live-migration function was triggered by customized Android based smartphone. We think this experimental use is pretty good, the time requirement for VMs migrating was a short period. However, the results were getting under the initial condition. The VM which are made heavy use of LMS has large size of virtual disk image. Therefore, the time of live-migration will need more than initial condition. We think we have to make the experimental use under the actual condition.

5. CONCLUSION

In this paper, we proposed a framework of disaster recovery 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 the results of experimental use and examine.

For the future, we are going to implement our disaster recovery framework on the cloud computing orchestration framework such as OpenStack [10]. And, we are going to try to experiment confirming its effectiveness under the inter-organization environment with multipoint organizations. In addition, we think it is needed reconfiguring an OpenFlow controlling method to become shortened for live-migration time.

ACKNOWLEDGEMENT

This work was supported by JSPS KAKENHI Grant Numbers 25350333.

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