Design of Multiple Clouds based Virtual Desktop Infrastructure Architecture for Service Mobility

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***Abstract*—Cloud service mobility has been more and more important for the next-generation Cloud service to support limitless movement and stable Quality of Service (QoS). But, existing virtual desktop infrastructure (VDI) solution has been provided from the fixed and dedicated single Cloud. In the situation, it makes several issues to long distance service users in aspect of response time, performance and QoS and so on. To improve the upper needs and problems, we propose multiple Clouds based virtual desktop infrastructure architecture and its functional blocks. Finally, we described use case of the VDI service in the proposed environment. The proposed VDI architecture can significantly improve the response time and stability of VDI service in case user moves to cross-border location.**

Keywords-Virtual desktop infrastructure; Cloud service brokerage; Multiple clouds; Service mobility; Interoperability.

I. INTRODUCTION

Recently, many companies and organizations start to use smart work environment through virtual desktop infrastructure (VDI) service to reduce the cost of management and infrastructure itself. And it is helpful for enhancing security level and realizing green computing. Moreover, the client devices of VDI service are transferring to diverse mobile devices from static PC and server according to mobile work trend. The VDI service may include company-specific business applications with high level security, office SW to handle various documents or favorite personal applications and so on.

In case that the employees in Korea leave on a business trip to another country, e.g., Germany, they still want to use their own VDI service to continuously perform the business work, to access to specific data or to enjoy favorite personal application. But, QoS of VDI service in Germany will be very serious because of degraded response time and performance by long distance transferring. Although this kind of inconvenient situation is occurred, they have to connect to the VDI service provided from Korea. This is very time consuming and troublesome job.

To ease the upper problems, we proposed the architecture and functional blocks of virtual desktop infrastructure in the multiple Clouds environment for enhancing the degraded QoS of VDI service when the user moves to another place, e.g., border-across movement. In the proposed architecture, the VDI service can be freely transferred among multiple Clouds according to user location (User Neighboring Service) and it makes the user to get more stable and high-quality VDI service in anywhere regardless of location.

II. RELATED WORKS

A. Cloud Service Brokerage

According to Gartner [2], Cloud service brokerage system is a role of intermediary, in which a company or other entity adds value to one or more cloud services on behalf of one or more consumers of those services. The Cloud service brokerage system offering will also often include some combination of capabilities that fall under three primary roles, aggregation brokerage, integration brokerage, customization brokerage. Gartner's Intermediation encompasses these three primary roles.

In [4], open source based Cloud service brokerage solutions are compared, according concerns like, system category and type, core capabilities, core features and advanced features, architecture and interoperability, service languages, programming model and service engineering, and quality. In this research, the authors place emphasis on the emergence of cloud service brokerage solutions on top of cloud management, the need for further separation of marketplaces and cloud service brokerage solutions and service description mechanisms to commoditize the cloud. Several organizations active in the cloud technology area have identified cloud service brokerage as an important architectural challenge. Architecture and programming model concern is key enabler of any service brokerage solution that mediates between different providers by integrating, aggregating and customizing services from different providers [5].

Cloud service brokerage system generally consists of three main parts that include user portal, brokerage core engine and Cloud connection management [3]. User portal is the front-end of the Cloud service brokerage system for Cloud service consumers and providers and it includes various business support functionalities. Brokerage core engine supports key functionalities for service brokerage, such as request verification, service provisioning, arbitrage, monitoring, service lifecycle management and so on. Finally, Cloud connection management is in charge of the interaction between Cloud service brokerage system and Cloud infrastructures by IaaS providers.

B. Virtual Desktop Infrastructure Service

Virtual Desktop Infrastructure (VDI) is used to run desktop operating systems and applications inside virtual machine that reside on servers. The desktop operating systems inside the virtual machines are referred as the virtual desktops. Through network, users access to the virtual desktops using VDI client that can be thin client, zero client or PC client. The client receives screen data of VM and displays it to the client display. Keyboard and mouse input of the client are captured and transmitted to the VM. Nowadays, there are several VDI solutions provided by VMware, Citrix, Microsoft, and KVM. The VDI systems are combination of the hypervisor and the VDI protocol. The representative VDI protocols are PCoIP, ICA/HDX, and RDP/RemoteFX. In the VDI system, Network Interface Card (NIC) for the virtual desktop is emulated by the hypervisor in software, and the emulated NIC is called as vNIC (Virtual NIC) [6].

The service flow of virtual desktop in single cloud is shown in Figure 1.

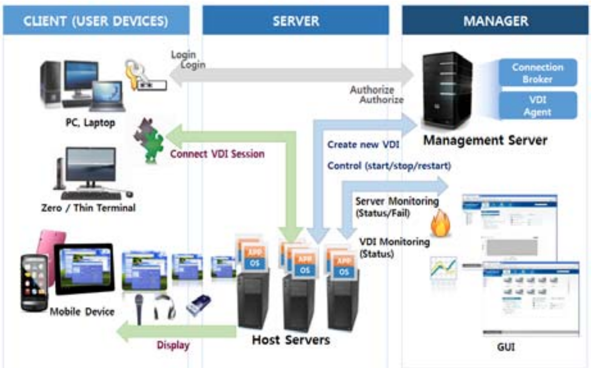

Figure 1. General VDI service architecture in single Cloud

VDI hosts a virtual desktop environment in a virtual machine that runs on a centralized or remote server. And user may access to the assigned VDI service through a variety of terminals. In general, VDI has three components as follows: one is a VDI client, which is user devices to connect to the VDI service, a VDI server in which user's virtual desktop exists, and a VDI manager that administrates and controls virtual desktop system. Virtual desktops in VDI server are transmitted to users' terminal using display protocol on network. These components are interconnected to support VDI service on network.

C. Nested Virtualization

In classical machine virtualization, a hypervisor runs multiple operating systems simultaneously, each on its own virtual machine. These solutions lack interoperability with each other, meaning that a VM running on one hypervisor cannot be easily migrated to another hypervisor, because it differs in several aspects, e.g., virtualization technique, virtual hardware devices, image formats and so on [7]. In nested virtualization, a hypervisor can run multiple other hypervisors with their associated virtual machines. It enables complete abstraction of underlying cloud infrastructure from the application virtual machines and allows deployment of existing VMs into the cloud without any modifications, mobility between the clouds and easy duplication of the entire deployment [8]. In this work, using multi-dimensional paging and multi-level device assignment, it can run common workloads with overhead as low as 6-8% of single level virtualization.

III. The Architecture of Multiple Clouds Based Virtual Desktop Infrastructure

In this section, we proposed the architecture of multiple Clouds based VDI and its functional blocks.

A. Architecture of multiple Clouds based VDI

In this section, we describe the concept and whole architecture design of multiple Clouds based VDI service. The system enables the unified management of heterogeneous cloud service providers and make VDI service to be moved across the diverse Clouds.

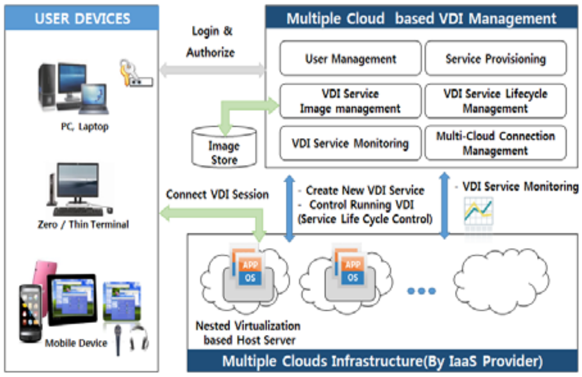

Figure 2. Architecture for multiple Clouds based VDI service

As showed in Figure 2, multiple Clouds based VDI service is consist of three separated parts, user devices, multiple Cloud based VDI management and Multiple Clouds Infrastructure. User devices are a kind of service terminal for VDI service users and it can be personal computer, thin client, laptop, mobile devices and others. Multiple Clouds based VDI management supports provisioning and management of the VDI host server and VDI service on multiple cloud environment. It interacts with diverse Cloud infrastructures and connects to the agent in each VDI host server for controlling VDI service lifecycle. Nested virtualization based host server is a shape of virtual machine including VDI host server. It enables complete abstraction of underlying cloud infrastructure from VDI host server in virtual machines and allows deployment of existing VDI host server into the cloud without any modifications between different hypervisors, e.g., KVM, Xen, VMware. Multiple Clouds Infrastructure consists of the diverse Cloud infrastructures provided by private and public Cloud service provider, that is, Amazon, KT, Rackspace, OpenStack and so on. And each part requires below features.

1) User devices
- Browser-based client system using HTML5
- Adaptive client service based on client resources
- On/Offline virtual desktop service

2) Multiple Cloud based VDI management
- Hierarchical management structure for large scale system
- Modular architecture for easy and quick virtual desktop provisioning
- Fast user image management system
- Web-based management interface

3) Nested Virtualization based Host Server
- Nested hypervisor, virtual hardware, network and storage configuration support
- Ability to run multiple VDI service on single host virtual machine
- Common abstraction and decoupling virtualized VDI server from resources provided by IaaS providers

4) Multiple Clouds infrastructure
- Diverse resource specification support
- Geographically dispersed Cloud resources
- Price, resource, security and other features can be selectable

B. Functional blocks of the multiple Clouds based VDI management

Multiple Clouds based VDI management is the essential part in the proposed VDI architecture and it intermediates most functions between user device and Multiple Clouds Infrastructures. In this section, we explained role of the detailed functional blocks in the Multiple Clouds based VDI Management. Figure 3 and figure 4 show its details and relationships between blocks.

VDI user portal receives various requests from users in the defined form and returns processed result via GUI interfaces. Users can control and manage their provisioned VDI services on multiple Clouds through it. User authentication and management has two kinds of roles, one is user authentication for VDI service and the other is account mapping between VDI service and each user or user group. Service provisioning is initial process to provide VDI service to user. It includes finding best-fit Cloud infrastructure for VDI services and makes required configuration and deploys VDI service on the selected Cloud infrastructure. VDI service lifecycle management reacts from monitoring alert, especially, SLA status monitoring and applies pre-defined policies to maintain recommended QoS. Possible reaction can be restart, stop, resume, suspend and move to another Cloud. User system image management is a kind of image repository which stores and retrieves VDI host server and VDI service image from/to IaaS provider's infrastructure. And it manages the version of specific user or tenant's VDI service image to keep the final updated information on the image. VDI service monitoring is responsible for measuring the Key Performance Indicators (KPIs) of the VDI services. In the proposed systems, it provides the data primarily for service accounting / billing and SLA management. Monitoring helps to diagnose hardware and software problems, to enhance the resource utilization and to ensure the service's performance and security.

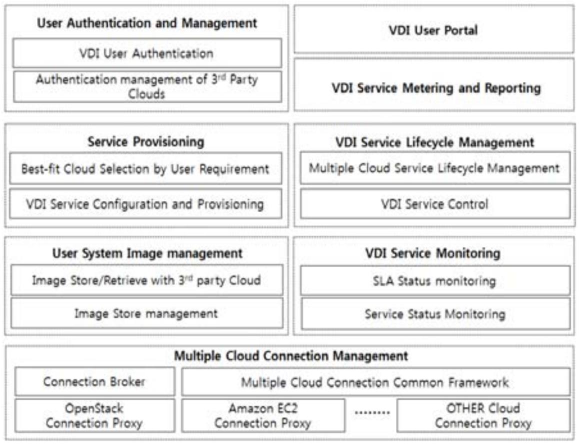

Figure 3. Functional blocks of multiple Clouds based VDI management

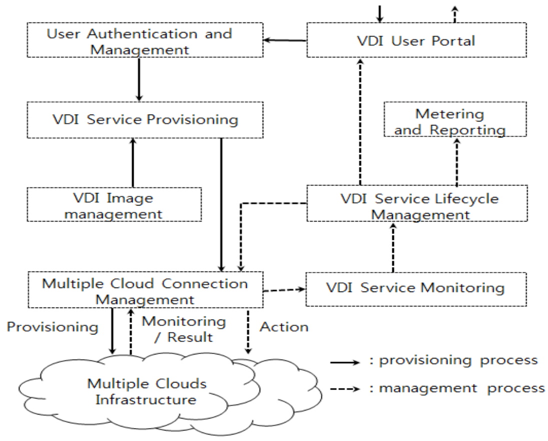

Figure 4. Relationship among main functional blocks

Multiple Cloud connection management deals with the interoperability interface between the VDI management system and the collection of heterogeneous Cloud providers. This component translates the requests from the provisioning and configuration component into understandable provider API calls. And connection proxy abstracts the existing API's heterogeneity through a common framework in the proposed system. It is also in charge of connection and management of VDI host server through connection broker with host server agent.

IV. USE CASE

In this section, we described the use case of the multiple Cloud based VDI service. In this use case, we assumed VDI service user moves to EU from Korea and wants to use his preferred existing VDI service in EU without service delay. Figure 5 shows overall operational sequence for the use case.

VDI Management server can interacts with diverse Cloud infrastructures through Multiple Cloud Connection Management block and communicate with deployed virtualized VDI host servers on it by host server agent. Virtualized host server is created by using nested virtualization technique. It enables complete abstraction of underlying cloud infrastructure from virtual VDI host servers and allows deployment of existing host server into the cloud without any modifications between the Clouds. The use case sequence is as below.

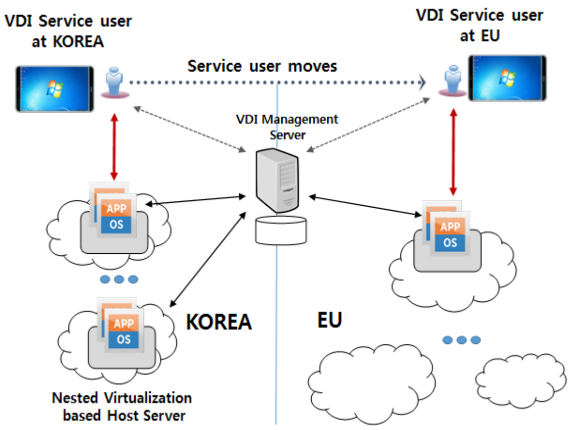

Figure 5. Use case for multiple Clouds based VDI service

1) User login VDI Management server to uses VDI Service in Korea.

2) VDI Management server deploys a VDI service in Korea Cloud and returns connection information to the user.

3) User connects to the allocated VDI service and uses it.

4) Service user has business trip to EU from Korea. Before moves to EU, user connects to VDI Management Server and finds best-fit Cloud infrastructure where user's VDI service will be migrated. To search best-fit Cloud, users can inputs diverse conditions, e.g., location, price, security level, usage period and so on.

5) VDI Management server recommends several EU Cloud infrastructures satisfying user's requirements and user selects and confirms the best one.

6) VDI Management server deploys VDI host server using existing virtualized server image.

7) VDI Management server connects to the agent in deployed virtualized host server and creates new VDI service. And it reflects differential data from existing VDI service to new created VDI service to maintain up-to-date status.

8) VDI Management server stop the existing VDI service in Korea and launches new VDI service in EU.

9) User in EU login VDI Management server and it returns new connection information to user.

10) User enjoys same VDI service from another Cloud infrastructure in EU without additional delay.

V. CONCLUSION

Most people have used the diverse and huge number of personal devices and they move frequently from one area to another. So, Cloud service mobility is very important for the next-generation Cloud service to support limitless movement and stable QoS. To satisfy the upper described needs, we proposed the architecture of multiple Clouds based VDI service and use case on its environment and designed the functional blocks of multiple Clouds based VDI management and defined the relationships among them. The proposed system architecture can improve the mobility and stability of VDI service in case the user move to cross-border location. Multiple Cloud based VDI service supports flexible service mobility using geographically dispersed Cloud providers and can be dynamically brokered to the best-fit Cloud infrastructure according to emerging demands.

In future plan, to verify usability of this work, we will compare service performance and stability between traditional VDI and the proposed VDI service. And we also consider container based architecture for better performance.

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