An Architecture of Virtual Desktop Cloud: Design and Implementation

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***Abstract*—This paper starts with an evaluation over the virtual desktop cloud technology and its applications in business and forecasts its development in the security and reliability of information systems. It then proposes an architecture of virtual desktop cloud based on the X86 platform. It finally presents the implementation of the architecture and describes how the architecture can significantly reduce the maintenance costs and upgrading cycle of computing systems and facilities.**

Keywords- virtual desktop cloud; sever virtualization; desktop virtualization

I. INTRODUCTION

With the development of computer technology and Internet technology, cloud computing is emerging as a web-based process by which shared resources, software, and information are provided to computers and other devices such as smart phones on demand over the Internet [1]. As terminal users increase rapidly in numbers, the demands for both computing resources and shared information are becoming diverse, which make the desktop management extremely complicated and expensive in system installation and maintenance [2].

Conventional IT systems are developed from a centralization paradigm with distributed PCs for independent users. Those systems have its advantages of customized desktop environments, but are difficult to maintain and are vulnerable to errors, risk and disasters. The desktop cloud system described in this paper enhances the security of the desktop environments. It adopts a centralized computation, but relies on the architecture to realize mobile and remote user applications, which represents so-call Private Cloud. The architecture of this system is explained below.

The Teaching and Research Center within the School of Information Science and Technology at the Shijiazhuang Tiedao University has more than 12 computing laboratories, with software and hardware being distributed in different floors and buildings. This computing facility can accommodate about 800 terminal users and is mainly equipped for meeting the educational demands such as postgraduate and undergraduate courses, tutorials and projects. The facility is incorporated with various modern computing technologies including .NET, Linux, JAVA, Database, 2D/3D engineering, to name only a few. In the early days, those computing laboratories relied merely on system recovery cards, isolation units and recoverable network devices to divide the computing resources (including software and hardware) into different sub-systems and sections. Tailored for different teaching courses, sectional systems had to be set and configured to meet the specific requirements.

In such a scenario, it means that every computing laboratory must install a number of different system configurations for different demands, which had made the overall facility complex and complicated, leading to a significant of management and maintenance costs. At the same time, due to the fast development of hardware and software, the lifecycle of terminal PCs are becoming shorter (upgraded and renewed for every 4 or 5 years), this has added on a large annual cost over the maintenance of the facility. On the contrary, as all other large organizations [2, 3 , 4], the budget for purchasing and maintaining computing facilities including PCs at Shijiazhuang Tiedao University has been tightly controlled and for some projects it has reduced, which has inevitably created a dilemma between the system upgrading and the management costs.

In the summer of 2010, the Institution started the project called virtual desktop cloud to bring the state-of-the-art technology and solutions to the aforementioned problems. The project, via virtual servers, is to integrate a large numbers of dedicated severs so that an optimize hardware configuration can be established to reduce the computing resources. Since the so-called Virtual Desktop Infrastructure (VDI) has already been widely implemented on the campus, computing resources previously in the user's desktops can be integrated from the distributed PCs into the data center through remote desktop protocol. The merits of such strategy are (1) to extend the life of PCs, (2) to improve the customer service quality and (3) to generate fast and repaid responses to the customer's requests.

The implementation shows that the virtual desktop technology has enabled PC customer's access their own virtual desktop through any network port or equipment and the computer lifecycle has been significantly extended. Because all virtual desktops have been integrated in the data center of cloud computing instead of being distributed over a population of single PCs, very little resource is needed for installing patch programs or security update in the individual PCs. All previously existing system management and maintenance tasks can be carried out in a cloud computing architecture (within the data center), which provided a much more flexibility and robust environment for students and enabled them to access their own personal desktop anywhere (and with much more mobility).

With the aforementioned application example, this paper presents a virtual desktop cloud and demonstrates its design and implementation as a web-based process by which shared resources, software, and information are provided to computers and other user-centered devices, proposing an architecture that is different from conventional IT centralization infrastructure [5, 6, 7].

In the text to follow, Section II describes the proposed system structure and Section III illustrates the work scheme of the system and Section IV demonstrates the functionality of the architecture. Section V provides a comparative study to validate and justify the architecture against the IT centralization paradigm. It also provides a brief description of user experiences in terms of the design flexibility and customization for different applications. Section VI shows conclusion and future work.

II. System Structure

Virtual desktop cloud technology integrates comprehensive virtualization technologies toward severs, OS's, desktops, thin client, remote link protocol, and so on [1]. Virtual desktop cloud solution differs from others in that it can deliver personal desktops to customers by using single mirrors. This solution simplifies desktop management and improves the service quality, by which system administrators are able to choose distributing systems more flexibly. This enables the system to distribute desktops to individual computing laboratories, remote libraries, staff offices and student dormitories.

With the current installation and configuration of the severs in the Teaching and Research Center in the School of Information Science and Technology at the Shijiazhuang Tiedao University, two virtual partitions are used where desktop virtualization platforms and DVC [1, 2] (distant visual cluster) software are involved. The first one has the capacity of supporting 400 desktop platforms, which is built through utilizing desktop virtualization platforms and enterprise-level severs and disk arrays. The second one is a distant visual cluster system built with high-performance computers with distant visual cluster software, which is mainly for graphical design and research projects on the campus.

A. *Architecture of VisualView Software*

The desktop virtual platform has an architecture that includes an end-to-end solution and can deliver desktop applications in the form of managed services [1]. This architecture is shown in Fig.1. The virtualization platform provides a highly scalable, highly reliable and stable platform for running virtual desktop applications, which has the continuity of services and disaster recovery functions to protect the user information and the desktop data [2]. The platform provides a guarantee for desktop virtualization, and is inexpensive and simple like traditional solutions. The management center can completely control and check clusters, host computers, virtual computers, memory, network connections and other key factors within the virtual basic architecture [3, 4].

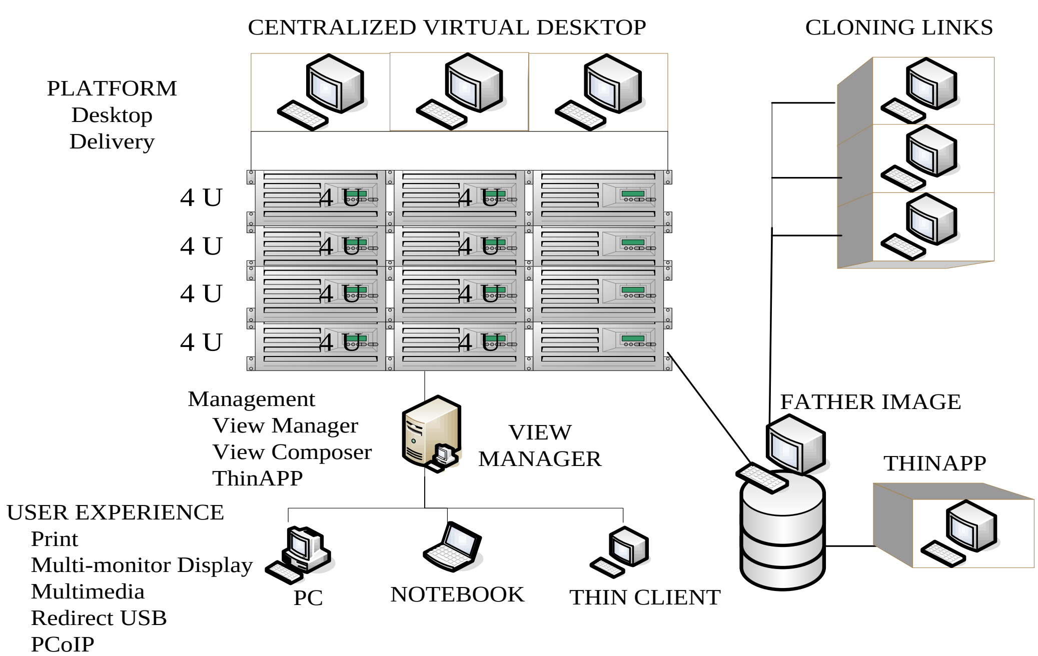

Figure 1. System Frame of Virtual Desktop Cloud.

The virtual manager software can in theory manage thousands of virtual desktops from a single memory image for controllers, which simplifies desktop management, allocation and deployment. At the same time, terminal users can access virtual desktops safely and easily through the Software-View Manager [4]. In an educational establishment, students are able to establish rapidly a desktop image shared with a single up-level image in virtual disks through virtual composers. The virtual composer may segment the user data and configuration for independent management, so it will not affect the user data and configuration whenever repairing and updating desktop linked with up level images need to be carried out [5]. The Virtual ThinApp simplifies the management and distribution of applications, which can rapidly dispose the applications to users and avoid any data transfer conflicts [2, 3, 4].

For software applications, the virtual manager is able to manage as many virtual desktops from a single memory image for controllers as they are needed. This arrangement simplifies desktop management, allocation and deployment. At the same time, terminal users can access virtual desktops safely and easily through the Software-View Manager [4]. Students are able to establish rapidly a desktop image shared with a single up-level image in virtual disks through virtual composers. The virtual composer may segment the user data and configuration for independent management, so it will not influence the user data and configuration whenever repairing and updating desktop linked with up level images need to be carried out [5]. The Virtual ThinApp enhances the functionality of management and simplifies the distribution of applications. This architecture can therefore rapidly dispose the applications to users and avoid any data transfer conflicts.

B. *Architecture of Distant Visual Cluster Systems*

The distant visual cluster DVC [6] adopts a C/S architecture including server-end and client-end. The server-end realizes OpenGL to accelerate the rendering cycles of user applications and it compresses the rendering image for a fast data transmission. For the client-end, it receives the compressed images and extracts to display on the monitors. The detailed architecture of DVC for these functions is shown in Fig 2. The sever-end is connected with the client-end through specific protocols. Virtual displays are virtualized by software in the server which directly sends 3D graphic operation commands to the 3D acceleration graphic card in the server-end. Test shows that this arrangement can significantly improve the rendering efficiency via utilizing accelerated rendering of 3D drivers. Events of mouse and keyboard can be sent to the client-end through the protocols in order to run applications in the server-end. These specific processes are list below.

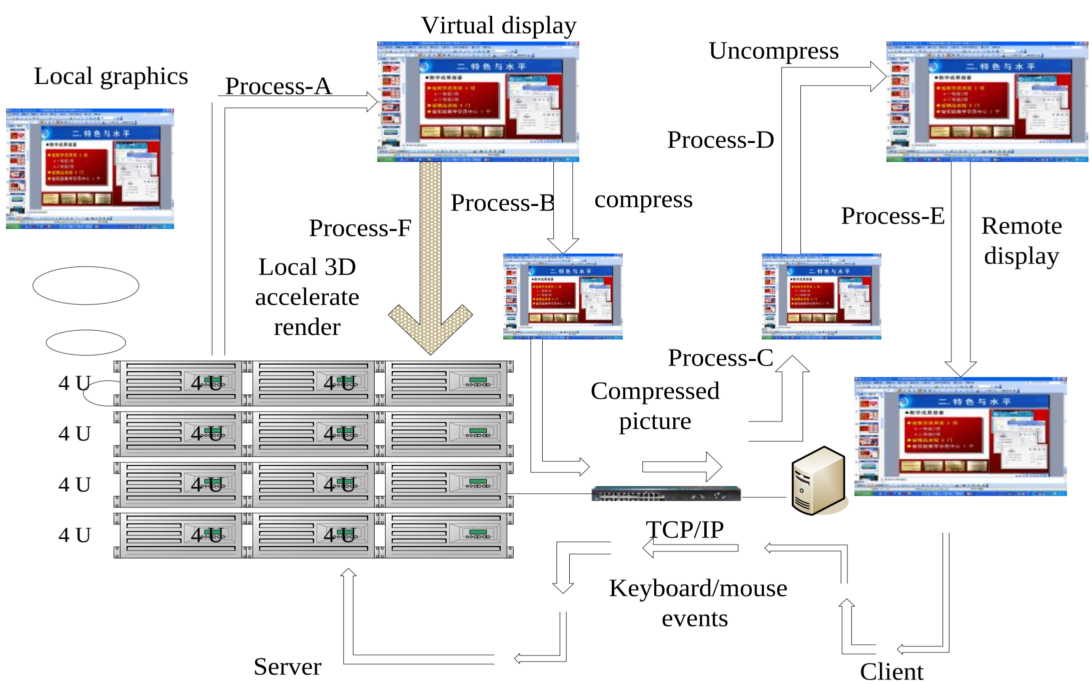

Figure 2. Architecture of DVC sytem.

1) Process-A: The local server-end utilizes the virtual display and the process-F to realize the hardware and the 3D accelerated rendering process in the server-end and it thus forms a 2D rendering graph in virtual displays which is of high-resolution and high-capacity [6].

2) Process-B: This is to compress the high-resolution and high-capacity rendering graph to small-capacity graphs that are suitable to transmit data in the network. It utilizes the image compression technology with high compression ratio.

3) Process-C: This process transmits the compressed graphs in the server-end to the distant client-end through internet.

4) Process-D: This decompresses the graphs and the graphs are received from the distant client-end.

5) Process-E: The rendering 2D graph and displaying in client-end are processed in this phase.

6) Process-F: The virtual displays send the accelerated rendering commands to the 3D accelerated hardware.

In the transmission between the sever-end and client-end, the arrow represents the transmission process of the mouse and keyboard events. From the above processes, it is shown that the geometric model of the rendering section with huge amount of calculation running on high speed graphic card and the 2D graphic compressed data packed is extracted and displayed on the monitor.

Data transmitted in the internet includes rendering graph and mouse and keyboard event instead of 3D geometric model data. This as a result substantially reduces the amount of data transmitting in the networks and decreases the dependence on networks, thus it improves the operations for graphic applications. This is one of the obvious advantages in employing DVC to realize distant 3D accelerated rending for applications.

III. DESCRIPTION OF SCHEME

A. Configuration of Virtual desktop Cloud Server

The configuration of the server used for virtual desktop cloud is listed in Table I. The server is a standard 4U rack which is an enterprise server whose main configuration can be simply summarized as below.

TABLE I. CONFIGURATION LIST OF VIRTUAL DESKTOP CLOUD SERVER

Standard 4U rack enterprise server	
Processor	Opteron 6134（2.3GHz，8 cores）*4
Memory	128GB ECC DDR3 1333 Registered memory; supporting advanced management function
Hard disk	146GB, hot-swap 2.5 inch SAS *2
RAID card	512MB SAS RAID card，with battery，supporting RAID0/1/5/6/10/50/60
NIC	2 port gigabit-NIC with 5 gigabit network interface
HBA cark	single port 8Gb PCI-E optical fiber HBA card *2
power	1+1 redundancy hot-swap power module
fan	Front 2+1 redundancy hot-swap fan
Management software	Integrated IPMI、iKVM、virtual media；distant management software, condition monitoring software for equipments; information management and distant access software; backup and recovery software for sever systems

The processor is an Opteron 6134 with 8 cores; the memory capacity is 128GB; the hard disk is 2 SAS hard disks with 146GB capacity.

B. Memory Configuration for Virtual Desktop Cloud

The memory configuration for the virtual desktop cloud has three parts which are as follows.

1) Requirements of memory capacity For the proposed architecture, each user is allocated with a 20GB disk. This capacity is determined for both systems described earlier. A 30GB disk capacity is used for data storage according to literature [6]. In total it needs 20TB disk capacity for 400 users.

2) Configuration of memory capacity Using a fiber channel storage array, a main cabinet and an extended cabinet, the configuration and distribution are list below.

a) The 16 600GB/block disks provide a 8.4TB bare space in which one block is used as a hot backup and the other 15 bocks constitute the RAID5 module.

b) The 14 1TB/block SATA disks is able to provide 12TB bare disk space in which one block is used as a hot backup and the others form the RAID5 module.

c) The system space is placed on the FC disks and the data space is placed on the SATA disks.

3) Storage performance The fiber channel storage array has 8Gbps channels and is constructed to provide a transmission capacity of 20000 I/O per second which is to meet the 400 I/O requirements designed for virtual desktop applications.

C. Planning of Network

The communication networks among severs use an independent 1000Mbps Ethernet, which is intended for the data transmission between the virtual servers. The design details of the network are listed in Table II.

TABLE II. PLANNING OF NETWORK

Equipment type	**Number**	**Detailed configuration**
HPC platform case	1	Independently supporting 5 nodes，2 gigabit exchange module， 2 management modules equipped with 2 2000W redundancy power modules, supporting UPS modules, memory modules and management PC modules
Workstation node	5	2*XeonE5620 /2*SAS2.5 inch 10K147G/ 24G/Nvidia Quatra FX3800 professional graphic cards
PC module	1	160GB hard-disk，processor and 1G memory integrated system with mouse, keyboard and monitor
DVC	1	Distant virtual workstation (cluster system)

This part describes the communication networks between the servers and the memories. The networks employ a two-

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link redundancy mechanism with two 8Gbps which are capable of preventing all applications from sudden shutdowns that may be caused by faulty devices or communication units.

D. Configuration of Distant Visual Clusters

The distant visual cluster includes one high-performance computer platform, five workstation nodes, one PC module, one UPS module and the corresponding virtual workstation cluster software.

Table Ш is the details for such a configuration. The communication network between server and memory has two sections, one has an 8Gbps FC and the other includes two link redundancy mechanisms. The communication network between server and server is a 1000Mbps Ethernet**.**

TABLE III. CONFIGURATION OF DISTANT VIRTUAL CLUSTER

Type	Design
Communication network between server and memory	A. 8Gbps FC B. two link redundancy mechanisms
Communication network between server and server	1000Mbps Ethernet

IV. SYSTEM FUNCTIONS

The system functions so far have fallen into two categories in terms of its structure design. One is based on the architecture and the other is on the cluster applications.

A. Architecture of Virtual Desktop

The virtual desktop employs an optimized cloud computing platform which serves as its underlying architecture. This platform provides efficient server virtual functions. As a background support, it has following five features.

1) Extensibility

Each management unit supports up to 1000 virtual machines, which makes it suitable for a large deployment of virtual desktops. By using vMotion [7], the system is made more efficient and faster than conventional IT infrastructures and the migration time can be shortened significantly. Depending on service demands and the priority to compress and add desktop applications, the server resource is able to distribute in a dynamic module.

2) High performance

vSphere, equipped with high performance, is able to provide a fast and stable platform for the virtual desktop applications and to obtain an optimal status of the servers and virtual machines by using the monitoring platform [7].

3) Optimum density

With the increasing density of virtual desktops, there are 16 to 20 virtual desktops per core, this can increase the numbers of the supporting machines in each sever.

4) High-availability and business connectivity

vSphere optimizes the workload of the desktops. The performance improves because of the reduction of the memory exchange.

5) Rapid disaster recovery

Both the data recovery technology and the vMotion [7] technology are able to provide the safety of the virtual desktop platforms.

The system administrators are able to use the virtual desktops as a central controlling node. This node supports terminal users for safe and flexible accesses to the virtual desktops and is able to deliver the desktops in a style which is called the managed security service model. The virtual management software possesses an expansibility and reliability and utilizes a management interface. This interface is formed for the Web services to create and update the desktop images, to manage the user data, to implement the global strategy and to manage and monitor as many virtual desktops as it is currently needed (about 1000) simultaneously.

B. Distant Visual Cluster Software

The 2D or 3D software is needed for routine teaching and research needs. Those software systems are used to meet visual demands for processing the exchanged data. Base on a number of tests and experimental tries, the solution of DVC has solved the aforementioned problems. The configuration of the system is described below.

1) Improving the security of data.

Distant users are able to access and operate the corresponding applications; there is no other data to transmit to the distant users except for the distant desktops which ensures the safety of the user data.

2) Improving hardware utilization.

By using the DVC software, one workstation can support a number of different users at the same time, thus improving the rate of facility utilization.

3) Improving efficiency.

Through the DVC software, staff and students are able to work anywhere and participate in a virtual environment that is efficient and effective.

4) Reducing management cost.

With the DVC software, the hardware and software can be integrated seamlessly, which effectively reduces the management costs, improves the operational efficiency and extends the life span of the systems that are involved.

V. COMPARATIVE ANALYSIS OF SCHEME

The above design and implementation has been used in a one year teaching and research environment as a testing period and the user experience indicates that the virtual desktop cloud solution is such an implementation that is able to support in an enterprise level the distant dynamic access of desktop systems and the unified managed technology of data centers. In comparison to the tradition IT systems, it is a new module that is based on servers and thin client modules so that system administrators and users can take the advantages of the two modules simultaneously.

The results show that all desktop virtual machines are trusted and uniformly managed in the data center. The users can have the same user experience as but better results than with the traditional IT systems via the thin client, the similar equipment in LAN or distant access. Especially under the virtual desktop cloud architecture, the openness and zero-touch of the cloud computing basic architecture can be realized. In the transaction process of shift toward the cloud computing from the traditional paradigm, robust data protection and full utilization of resource can be achieved.

The vSphere can realize a free migration between the servers and the virtual machines. This will help in realizing an automatic detection of fault. It can also obtain the distributed resource allocation to realize a balanced workload among applications. The vMotion can help in achieving the real-time migration between running servers, obtaining zero-shutdown characters, which is able to enhance the availability of the servers and to increase data security.

It is also justified in the testing period that the virtual desktop architecture provides a safe and reliable data storage center, protecting the users from data loss, virus entry and other online hazards. A convenient and fast 'could server' can reduce the workload compared to the old daily maintenance work. It is verified that the system administrators are able to carry out easily the maintenance work including maintaining hardware, installing and updating software, preventing virus and network attacks. Finally, users only need to type their address or login details to access the system and carry out the work exactly the same manner as on PCs. Cloud computing provides almost infinite space for storing and managing the data and provides the most so far capability for completing large applications.

However, as for information security, user experience, existing bandwidth, product type choosing and allocation respects, the virtual desktop planning still face many technical and commercial challenges. For security and privacy of personal data, identity authentication and data backup should be enforced to ensure the high reliability and availability of data in the implementation phase. Since various mobile storage devices are being used today, printing and transmission of streaming media data may restrict the users to access the virtual desktops and their application data.

VI. Conclusion and Future Works

In order to realize IaaS (Infrastructure as a Service), PaaS (Platform as a Service), SaaS (Software as a Service) of computing resource and to simplify terminal units, system resources should be integrated and managed in cloud units to improve the system efficiency and enhance the service quality. The architecture of virtual desktop cloud makes it possible for different computer systems and computing resources to be managed centrally in the data center and distributed through the network in service modules. This makes it possible meet the user's demands. By integrated management of computing resources, idle computing units and storage can be reduced substantially.

Future works are needed to (1) carry out further study toward empirical validation of the system so that the proposed architecture can be justified for its claimed functions; (2) the development process needs to be further validated and more user experiences need to be gathered to examines the merits and failures of the design and implementation, especially the design flexibility for new required features and the customizing ability for different applications.

VII. Acknowledgment

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