Computer teaching based on experiments using a virtualisation platform

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ABSTRACT: Common problems in computer science and technology teaching using experiments in university are analysed, and the idea is proposed that virtualisation technology be employed to improve the existing experimental environment. Specific implementation plans of a virtualisation platform for an experimental teaching centre are provided. In the actual teaching process, the deployed virtualisation platform was tested and the effects of its application analysed. The results show that the virtualisation platform, if well operated, meets the demands of experimental teaching and dramatically increases laboratory utilisation.

INTRODUCTION

As a practical subject, computer science and technology teaching should include experiments, as well as theory. The experiment teaching centre at Wenzhou University is responsible for creating the environment required by theoretical courses. Currently, most teaching laboratories with computers only provide a simple stand-alone on-line environment for students. In order to meet the requirements of the curriculum, each computer needs a large number of disparate software systems installed. Protective measures need to be in place to avoid mutual interference between the systems for different courses. Low use or high use may affect such experimental equipment.

There are many issues that arise in this situation. For example, the performance of laboratory computers may be degraded due to having too much software installed. Using a single computer may not be satisfactory for some experimental practice. The opening hours of some laboratories may not meet the demands of students and, therefore, it may be difficult for the laboratory management staff to maintain the systems, and so on [1-2].

In light of the problems presented above, many teachers have innovated the courses that they conduct [3-4]. However, these changes are only suitable for single courses and so the laboratory is only partially optimised. The overall layout of the whole experiment centre has not been analysed. Some researchers have proposed establishing a unified virtualisation experiment centre [5]. However, this idea only remains a theoretical target and there is no specific implementation planned. In order to solve the above problems, details are given in this article for the construction of the experiment teaching centre and implementation plans for the construction of a virtualisation platform.

VIRTUALISATION TECHNOLOGY

Virtualisation is a broad term that usually refers to computing elements that are operated on a virtual basis rather than a real basis. Virtualisation technology can expand the capacity of hardware and simplify the reconfiguration of software. Virtualisation technology can enable a single-CPU to simulate the parallel operation of a multi-CPU system or allow several operation systems to run on the same platform. At the same time, application programs can operate in independent spaces within the computer and without mutual interference; thereby, significantly improving efficiency [6].

Compared to the traditional operating system resource allocation, virtualisation has the following advantages: the potential to greatly improve resource utilisation and to provide separate, safe and efficient application execution environments. The virtualisation system also can be easily managed and upgraded. More mature virtualisation technologies have server virtualisation and separate desktop virtualisation. Desktop virtualisation is better suited to building the experimental environment.

Desktop virtualisation is focused on desktop applications and involves a simulated, distributed operating environment, which is an improvement over existing desktop management systems. The desktop components (hardware, operating system, application programs, user profiles and data) are all linked together in the current desktop environment. This presents great difficulties for the support and maintenance of the components. When the desktop virtualisation technology is adopted, it will be no longer necessary to arrange and manage several software client systems on each user's desktop.

All the application client systems will be deployed on a dedicated server in the data centre. This server is connected to the application server. The client will not be required to send the actual data to each user through the network system. Only the virtual client interface (screen image update, buttons and mouse movement, etc) are transferred and displayed on the user's computer. This process will be straightforward for the end-user, who perceives the actual client software running on his/her desktop.

CONSTRUCTION OF THE VIRTUALISATION PLATFORM OF EXPERIMENTAL CENTRE

Combined with the available hardware, the virtualisation platform is designed as an environment in which 100 virtual machines are simultaneously available on-line.

Software and Hardware Requirements of the Platform

The existing providers of virtualisation software products include Citrix, Microsoft, VMware and other large companies. Of these, VMware stands out as being particularly advanced and, therefore, VMware virtualisation software was selected.

The following aspects were considered in choosing hardware: the size of the CPU, the size of memory, the amount of disk space, the capability of the server disk in inputs/outputs per second. As well, the performance of the whole network should be considered, together with some other aspects [6]. Taking into account the above factors, the following were selected: eight HP DLL88 G7 servers (12 core CPU at 2.4GHZ and memory is 24Gbytes), two sets of external data memory and two CISCO Gigabit Switches.

Network Topology of Platform

The existing eight servers are considered ESXi servers. The server has dual Network Interface Controllers (NICs) which respectively forms two different subnets. The NIC1 is combined with two external data storages forming subnet 1. This subnet is responsible for data transmission between the server and the data storage using Gigabit Ethernet. The NIC2 is combined with the PC terminal to form subnet 2. This subnet is responsible for the communication between the devices and the server using 100Mbit Ethernet. The network topology is shown in Figure 1.
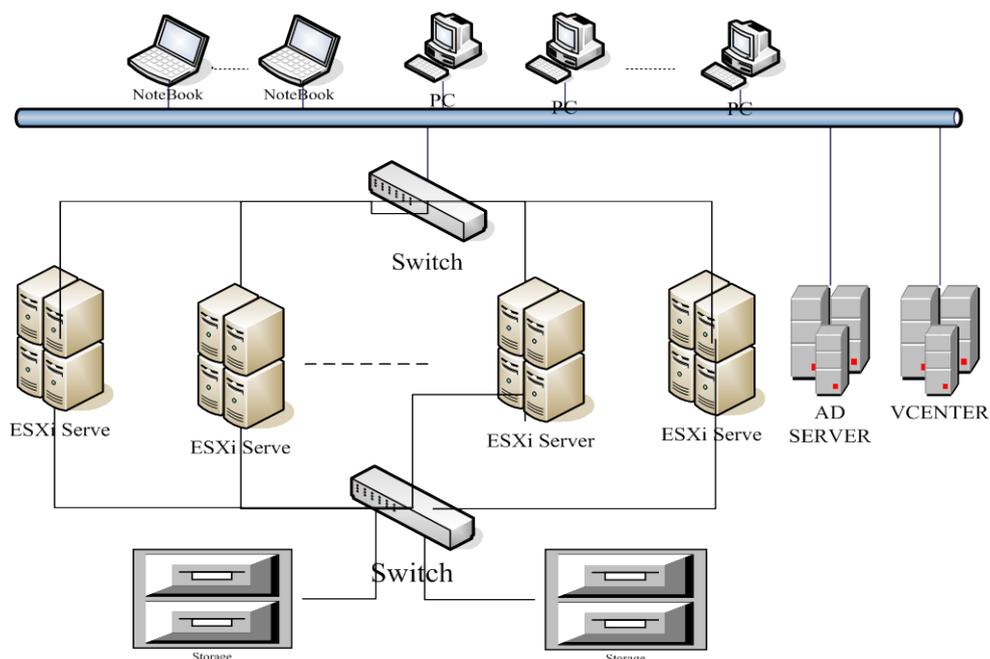

Figure 1: The network topology of the virtualisation platform.

Installation and Configuration of the Virtualisation Platform

The laboratory is configured taking account of security, flexibility and the maintainability of the system.

Configuration of the Experimental Environment

The eight servers are put together to establish the cluster, and the HA (High Availability) and DRS (Distributed Resource Scheduler) functions of the cluster are opened. All the virtual machines are stored in the external data storage. The configuration of the experimental environment is shown in Table 1.

Table 1: Configuration table of environment.

Server role	Operating system	Computer name	IP address	Installation media
ESXi Server	ESXi 5.0	ESXi1.book.com-ESXi8.book.com	10.132.251.1（192.168.100.11） 10.132.251.2（192.168.100.12） 10.132.251.3（192.168.100.13） 10.132.251.4（192.168.100.14） 10.132.251.5（192.168.100.15） 10.132.251.6（192.168.100.16） 10.132.251.7（192.168.100.17） 10.132.251.8（192.168.100.18） DNS:10.132.251.11	
Domain controller	Windows server 2008 R2 X64	AdESXI.book.com	10.132.251.11	
VMware vCenter	Windows server 2008 R2 X64	vCenter.book.com	10.132.251.12	1. VMware vCenter 2. View composer
Connection server	Windows server 2008 R2 X64	Connection.book.com	10.132.251.13	Connection server
Storage	Linux		192.168.100.1 192.168.100.2	

Establishment of the Template Library

The template is the master copy of a virtual machine that can be used to create and prepare a new virtual machine. This image will usually include the specified operating system and the configuration; it provides a virtual copy of the hardware components.

Different operating systems are required by different courses. Therefore, the basic template libraries include WindowsXP, Windows7, Windows2003 Server and Ubuntu (a Linux based operating system). The teachers can select their own basic system template and add their own software programs to form a curriculum template library.

Generation of the Virtual Desktop

VMware View is employed to develop the virtual desktops for different templates, with each batch consisting of 30 machines. It is necessary to build student accounts in advance. The students can independently use the virtual machine through binding of accounts and the virtual desktop.

TEACHING IMPLEMENTATION OF THE VIRTUALISATION PLATFORM

After the construction of the virtualisation platform, it was tested in a teaching setting in order to understand the stability and the applicability of the platform.

Teaching Implementation

Some courses have used the virtualisation platform, but some have yet to, e.g. open experimental projects and graduation design projects. The courses used in the trial include the following: Large Database Systems, Management Information Systems, Principles and Applications of Customer Service, Integration of Information Systems, Electronic Commerce and Principles and Applications of Databases.

The experimental open projects include Replication Technology of MySQL Databases, Replication of SQL Server Databases and Disaster Recovery of Oracle Databases. At the same time, there are research experiments, some of which include the graduation designs of undergraduate students and the research of graduate students. The contents of these experiments (practice) are shown in Table 2.

Table 2: Explanation of some experiments based on the whole platform.

Project Name	Experiment object	Number of people	Unit/Number	Category of experiment	Explanation
Large Database Systems	07/08/09/10 about six classes	220	Windows Server/2	Experimental teaching	Providing two Oracle database servers
Management Information System	08 Information Management	42	Windows XP/42	Experimental teaching	Application of e-commerce is realised in Xamp architecture
Principles and Applications of Customer Service	08 Undergraduates of Computer Science/08 Undergraduates of Computer Science/07 Undergraduates of Information Management	120	Windows XP/60	Experimental teaching	Configuring the development environment and allowing the students to practise
Integration of Information Systems	07 Information Management	23	Windows 2003/60	Experimental teaching	Good experimental results of NLB (network load balancing)
Electronic Commerce	07 Information Management	48	Windows 2000/40	Experimental teaching	It is not a problem if the experiments are deleted
Principles and Applications of Database	09/10 three classes	105	Ubuntu Linux/2	Experimental teaching	Providing the 65 MySQL user databases
Replication Technology of MySQL Database	08/09 Electrical Major	6	Ubuntu Linux/2	Open experiment/18	Master-slave MySQL Server
Replication of SQL Server Database	08/09 Electrical Major	6	Windows Server/3	Open experiment/18	Virtual machine is installed with SQL Server2005
Disaster Recovery of Oracle Database	08 Electrical Major	4	Windows Server/2	Open experiment	Realising Oracle Data Guard system
Design and Realisation of Hadoop	07 Information Management /07 Undergraduates of Computer Science	2	Linux/4	Graduation design of undergraduate students	NameNode(1)+ DataNode(3)
Graph Mining of Biological Information	08/09 Graduates of Computer Applications	3	Windows XP/1	Research of students	Design and comparison of graph mining algorithm

Effects of Implementation

Several aspects influence the creation and the use of the system. These include effects on the students, the teachers and the experiment centre. The following points summarise the effects:

Solving the Problems Associated with Different Experiments Occurring on Different Courses or within the Same Course

The original experiment is only a part of what is required. Many students may perform well, but still do not master some operations outside the experiment or even within the experiment. For example, there could be a student who is good at ASP.NET programming, but does not know how to manually register .NET components in IIS (Internet Information Server), because teachers have already prepared the ASP.NET environment for the experiment. The virtual machine can help solve this; thus, improving the capacity for self-exploration.

Using Students' Sense of Ownership to Stimulate Enthusiasm

In a traditional experiment, students will change computers at the completion of an experiment. Hence, they do not have a sense of ownership of the system. The relationship between an experiment and the next experiment is not enough to create a feeling of ownership. Students, generally, are indifferent to imperfections in an experiment because at its completion, they are left with a positive attitude towards it. Using virtual machines, students can, in a sense, *own* the system required by a curriculum. If an experiment is not finished, subsequent experiments will be affected. This

backward phenomenon will have a negative impact on the students, which in turn encourages further effort. Conscientious students will pay more attention in hopes that *their own virtual machine* will reach perfection during the experiment.

Creation of Exploratory Experiments

The machines in a conventional laboratory cope with the common demands of many courses. They cannot, however, provide the multi-host environment for the experimenters, especially, in regards to the graduation design, the open experiment and scientific research. Based on the virtualisation environment, projects were completed including database clustering, replication and distributed processing, e.g. such as the construction of an Hadoop application system, the disaster recovery using MySQL/SQL Server/Oracle and projects based on graph mining applications. Practical aspects are included in some graduate courses so as to strengthen the practical ability of graduate students.

Teaching Evaluation

Initially, a method that can check the status of each student's test machine through accessing the student's virtual machine has been designed to track and evaluate the experimental process and results.

Improving the Management Efficiency of the Experimental Centre

Currently, the conventional laboratory must ensure the normal operations of each machine. When an abnormal situation occurs, it requires efficient maintenance in a timely manner. After the introduction of a virtualisation platform, cloning and migration can be employed to rapidly achieve a recovery. The reliability of the virtualisation platform is obviously higher than an ordinary desktop PC due to the use of the server plus network storage mode.

Promoting the Construction of the Experiment Teaching Demonstration Centre

The promotion of virtualisation technology in experimental teaching changes the construction of the laboratory, which creates a new situation requiring changes in the laboratory. All of them can promote the entire reform of laboratory teaching. The experiment curriculum model also requires the co-operation of related teachers. Adopting the visualisation system at Wenzhou University has resulted in:

- Reduced investment in laboratory hardware; improved management of laboratory equipment; flexible arrangement of laboratory space for experiment teaching.
- Adjusted and reformed content of experimental teaching; guiding teachers on participating in the construction of experiment teaching; inducing changes of the entire teaching system.
- Improving the practical skills of undergraduate students in an IT major; helping the students to comprehensively understand information technology.

CONCLUSIONS

The construction of a virtualisation platform for an experiment centre can improve the situation of inadequate investment and insufficient resources at universities and improve the management of the technology. Hence, this provides a feasible approach to a new teaching model.

The experiment teaching platform with virtualisation technology not only improves the utilisation of the laboratory, but also meets the diverse, complex and varied demands of computer experiment teaching. With the continuous improvement of virtualisation technology, the virtual concept and virtual technology solutions will play more active roles in the construction of experiment teaching platforms.

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Computer viruses: Theory and experiments. Computers and Security, June, (1987). [2] D. Chess and S. White. An undetectable computer virus. In Proceedings of the 2000 Virus Bulletin Conference (VB2000), (2000). [3] VMware, Inc. VMware Converter User's Manual , Version: 3. 0 RC, Palo Alto, CA, Dec (2006). Â These analysis environments use a combination of API hooking and/or API virtualization, which are detectable by malware running at the same privilege level. In this work, we develop the fully automated platform to trace the native API calls based on secondary development of Xen and have obtained the most transparent and similar system to a Windows OS as possible in order to obtain an execution trace of a program as if it was run in an environment with no tracer present. Virtualization is being used by a growing number of organizations to reduce power consumption and air conditioning needs and trim the building space and land requirements that have always been associated with server farm growth. Virtualization also provides high availability for critical applications, and streamlines application deployment and migrations.Â Advantages of Using Virtualization. Todayâ€™s IT intensive enterprise must always be on the lookout for the latest technologies that allow businesses to run with fewer resources while providing the infrastructure to meet today and future customer needs. Virtualization utilizing Intel Virtualization Technology is the cutting edge of enterprise information technology.