Teaching Online Information Systems Courses with Virtual Machines

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ABSTRACT

This paper considers the issues on setting up online computer labs for teaching the information systems courses that require intense hands-on practice. Due to limited technical support, budget, and space, it is always a challenge for a small university to implement online teaching for courses in the information systems curriculum. Often, faculty members in a small university need to be involved in the construction and management of online computer labs in addition to their normal teaching and research workload. The virtual machine technology can be used to ease some of the burdens of online computer lab construction and management.

1. INTRODUCTION

As the Internet technology advances, more and more courses are taught online now. Many academic fields have developed effective solutions for online teaching and learning. Generally, for courses with no lab activities, such as some of the courses in English, history, and education, the implementation of online courses are relatively easy. Many commercial learning management system (LMS) software packages such as WebCT are available to support this type of courses. Instructors post lecture notes, images, and assignments on a WebCT. Students read the online course content or download the files and read the materials off-line. LMS can also be used as knowledge management such as grading, hosting discussion groups, and presenting multimedia course content (Itmazi and Megías, 2005). For many information systems courses, this way of online teaching is not adequate because hands-on practice is a very important part of the curriculum.

Using the virtual machine technology can effectively overcome many difficulties for online hands-on practice. The Virtual machine technology can be used to create online computer labs that meet the requirements of teaching and hands-on practice. Two popular virtual machine software packages are VMware and Microsoft Virtual Server. The virtual machine technology has been used in computer technology certification training (Lammle & Tedder, 2003). When purchasing training materials, virtual machines are provided to simulate underlying IT products for learners to perform hands-on practice off-line. For the off-line use of the virtual machine technology to teach technology-based courses, the author can only find one report by Correia and Watson (2006) who used the software VMware to create 60 virtual computers for teaching computer network courses. The use of the virtual machine technology in constructing online computer labs is still in its early stage. There are few publications available.

This paper will first discuss the difficulties for teaching information systems courses online. Then, it will describe the virtual machine technology and how it can be used to support the teaching and hands-on practice for some information systems courses. This paper will provide some information about the advantages of using the virtual machine technology and possible hands-on activities that can be accomplished by using the virtual machine technology. It will also discuss some design and management issues. The last topic to be covered in this paper is about students' responses to the online information systems courses.

2. DIFFICULTIES IN PERFORMING HANDS-ON PRACTICE ONLINE

Unlike students in other fields, our information systems students have to play the roles of system administrators, network managers, and database administrators. It is inevitable that they will learn through mistakes made in operating systems, networks, and database management systems. An online information systems course needs an online computer teaching lab to support these hands-on activities. Some difficulties encountered in developing this kind of online computer lab are:

- Setting up fully functioning online computer labs requires sophisticated skills and experience in developing remote access services, enforcing security measures, and creating a highly interactive Web site. Often, the labs are built on the client-server architecture with a highly secured remote access mechanism. To better support the needs of students and faculty members, lab technicians should also be knowledgeable about the course content and should be able to update the online computer labs according to the current IT trend. Faculty members also need to fully understand the technologies used in the online lab.
- It is expensive to create and manage online computer labs. In our information systems curriculum, many of the courses require some lab activities on IT products. The requirements for hardware and software are different for different courses. It is difficult for small universities to cover every course with different technology requirements. The labor cost is also a great concern. Many small universities do not have the budget to support an experienced technical support team or hire consulting companies for constructing and managing the labs.
- It requires great effort to manage online computer teaching labs. The course content in the information systems curriculum is changing rapidly. The course content is often updated every semester. It takes a group of technicians to frequently redesign and update the online computer labs. Many small universities may not have dedicated computer service staff for daily maintenance of these computer labs. It is a nightmare for a small computer service department to handle so many different technologies and to update these technologies so frequently.
- Technical support is another difficult area. Many of our students are new to the lab facilities. They have little experience on using the hardware and software in the lab. Even worse, students in some information systems courses such as network management and database administration have to be given the system administrator' privilege in order to perform server-side operations. From time to time, students crash the operating systems, networks, or databases because of wrong configurations or other mistakes. When technical problems occur, it is difficult to get technical support due to lack of detailed information about students' projects and the shortage of technicians on campus.

Because of these difficulties, many hands-on based information systems courses are not fully online. Some of the online information systems courses require students to purchase the necessary technologies for hands-on practice. Many of our students cannot afford to purchase all the required hardware and software. Even if some students are able to purchase all the hardware and software for their classes, they may configure them differently; which may cause problems that prevent them from conducting some of the hands-on activities.

3. SOLUTION

As described above, many small universities have limited budget, limited technical support, and high demand for lab resources. Among the possible solutions for dealing with the challenge, the virtual machine technology provides a low cost, secure, and manageable solution. Virtual machines use software to accomplish the functionalities of hardware devices. On a physical computer, multiple virtual machines can be created and each can be installed with a different operating system and application software. These virtual machines can run concurrently

(Nathaniel Martinez, 2004). Originally, virtual machines are used to construct a testing environment for software and hardware consolidation. The technology reduces security risks and enables developers to quickly reconfigure computer systems for different testing tasks without the fear of destabilizing the systems for other users. For us, such a technology can be used to overcome the difficulties in developing an online computer teaching lab. The following are some of the advantages of the virtual machine technology when used for teaching online information systems courses.

- Affordability: Since multiple virtual computers can run concurrently on a single physical computer, it significantly reduces the cost and lab space. Even a small university can afford virtual machines.
- Flexibility: These virtual computers can communicate with each other through a virtual network created on the same physical computer. More importantly, virtual computers can be accessed through the Internet so that students can remotely access the online computer lab from anywhere and at any time. A virtual computer allows the lab developer to experiment with various lab configurations for different information systems courses in a fast and easy way. It is a great platform for the frequently updated computer labs.
- Manageability: The maintenance of virtual computers is relatively easy. You do not need to maintain network cables, power cords, and many other hardware devices. If a virtual computer crashes, you do not need to reinstall all the software. Instead, you can create a new virtual computer in a few minutes and link the newly created virtual computer to an existing backup of the virtual hard drive.
- Security: The virtual machine technology provides a much securer solution for teaching online courses. Students do not need to have the administrator's privilege for the physical computers. All they need is the administrator's privilege for the virtual computers. In such a way, students can only experiment with their own virtual network system and they have less chance to damage the university's network.

With the advantages mentioned above, the virtual machine technology is promising for teaching information systems courses.

For online use of the virtual machine technology, you may need another virtual technology, Virtual Private Network (VPN). Instead of using a physical network such as leased phone lines from a telephone company, VPN uses virtual connections to communicate with remote computers through the Internet. More information about VPN can be found in the book by Snader (2005). The following are some advantages of VPN.

- VPN allows students to log on to the online computer lab from anywhere and at any time through the Internet.
- VPN can be configured to allow students to log on to the online computer lab without directly working on the university's internal network. This greatly reduces the network's security risks.
- VPN provides the broadband Internet compatibility which is essential for GUI based hands-on practice.
- The cost of the VPN software is minimal. Operating systems such as Windows Server 2003 includes the VPN utility.

On the other hand, the virtual machine technology is not perfect for everything; the following are the restrictions that we may encounter when developing this kind of online computer lab.

- Due to the fact that multiple virtual computers are sharing the same physical computer, the performance of virtual computers in general is slower than that of a physical computer itself. This is not a serous problem for our lab activities since most of the lab projects are small projects when compared with the real enterprise level projects.
- Usually, for GUI based hands-on practice, we need a broadband Internet connection. Fortunately, most of our students have a broadband connection at home. For those who do not have broadband connections, they can go to a public library, or local community college campus to access the Internet.

In the next section, I will briefly describe how the virtual machine technology is used to support teaching and hands-on practice for various courses in the information systems curriculum on our campuses.

4. DESIGN OF COMPUTER LAB FOR ONLINE TEACHING

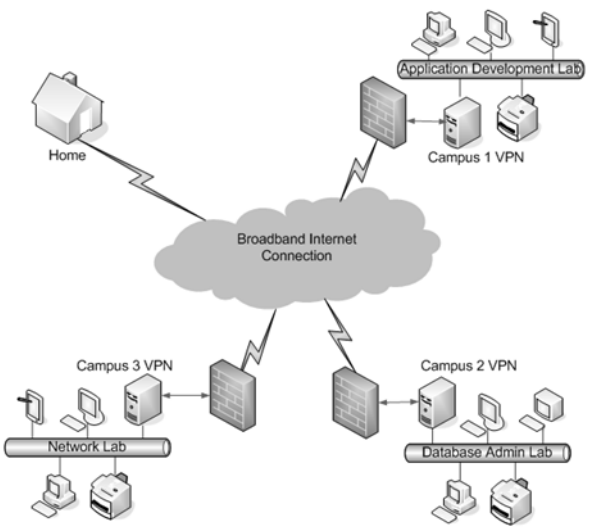
With the virtual machine technology, we are ready to develop an online computer lab for teaching various information systems courses that require intense hands-on practice. In this section, we will investigate how the virtual machines are used for supporting multiple information systems courses concurrently.

The first task is to investigate the requirements by the information systems courses. The courses that require hands-on practice can be classified into the following categories.

- The courses such as networking and system administration must allow students to have an administrator's privilege. Students will need to install and configure a network or operating system as part of their hands-on practice. No other courses should share the same computers with these courses since after reconfiguration, students of other courses may lose all their work or even are unable to log on to the computer system. The virtual machine technology is the best solution for this type of course.
- Students in the courses such as database administration or other application administration related courses must have the administrator's privilege for database servers and application servers so that they can perform the server-side administration tasks. The courses using various servers may share the same physical computer since the reconfiguration of one server normally has minimal impact on the other servers.
- In an information systems curriculum, courses related to application development and programming languages normally require a secure and stable physical computer as the server. The application development courses such as Database Application Development should not share the same server that also supports the Database Administration course since the reconfiguration of the database server can wipe out the database content created by the students in the application development course or prevent the students from other courses to log on to the database server. The virtual machine technology is a good platform for hosting the servers for application development courses on different virtual computers.

As mentioned earlier, the performance of virtual computers is a major concern. Due to limited budget, purchasing more powerful computers is often not an option for many small universities. One of the possible design options is to distribute the computing tasks to multiple less powerful computers. We can do that at different levels. First, let each physical PC host three or four virtual computers. In such a way, twenty PCs can host sixty to eighty virtual computers. Each virtual computer can handle a specific task. Next, to reduce network bottlenecks, we can distribute the VPN servers to multiple locations. As an example, consider our university which has three small campuses and each of them has the limited computer resources. To meet the needs of teaching and hands-on practice, a distributed computer lab can be constructed with three small labs, one on each campus. In such a case, we

Figure 1. Distributed online computer lab



can set up one VPN server for each campus. Each campus will host a computer lab that can support a certain type of courses. For example, the first lab can be used to support the network administration related courses, the second one can be used to support the database administration related courses, and the third one can be used to support the application development courses. The following figure demonstrates the design of the distributed online computer lab.

In Figure 1, the client computers such as students' home computers or notebook computers need to be configured so that they are able to remotely access the VPN servers. Based on the class enrollment, each VPN server has the local accounts for these students so that they can log on to the VPN server. Through the VPN server, the students can access each individual physical computer in the lab for hands-on practice. Each individual physical computer does not have to be an up-to-date powerful PC; a low-end Pentium IV PC has enough power to handle the hands-on practice for the information systems courses. Even the older Pentium III computers can get the job done if they are equipped with adequate memory for running the virtual computers.

5. EVALUATION OF ONLINE COMPUTER LAB

Our online computer lab has been used for two semesters. Is it a satisfactory solution in supporting online hands-on practice for information systems courses? We are also interested in what makes students take the online courses supported by the virtual technology and their reaction to this type of online courses. The response from students can be used as a guideline for further improvement.

At first, we were not sure whether it is doable to teach courses that require intense hands-on practice online, especially, to teach the information systems courses that require operations on the server side. To be on the safe side, we offered two sessions for each course, one session was a traditional face-to-face class, and the other one was a complete online class. The same instructor taught both sessions and the same teaching materials were used for both sessions. To give the students in the face-to-face class a chance to experience the online computer lab, we also permit them to use the online computer lab for their hands-on practice. Similarly, the students in the online session can participate in the face-to-face class and use the computer lab on campus. Initially, 42% of the students chose the face-to-face session and 58% of them chose the online session. At beginning of the semester, a survey was conducted to collect information about the students' background on taking online courses and the reasons that made them choose the online session over the face-to-face session, and vice versa. For the online session, the responses to some of the survey questions are listed in Table 1.

According to the survey results, the reasons for students to choose an online session are mainly due to the considerations of their job schedules, family activities, and class schedules. The students can take advantage of an online course to resolve the time conflicts. As indicated by the survey, 95% of the students have some knowledge or familiar with the course content and therefore they have confidence that they can handle the course work on their own. Other significant findings are: 100% of the students can access the Internet through their home computers and 95% of them have broadband Internet connections; 94% of the students use Windows XP Professional to access remote servers and 100% of the students can use their computers for online chatting and connecting to the VPN servers. A majority of these students are part time students. Only a small percentage of the students do not have the broadband Internet connection which is necessary for performing the hands-on practice using an online computer lab. For these students, we have arranged them to go to the nearest college campus to access the online computer lab. On the other hand, we are also interested in why some students chose the face-to-face session over the online session. The survey results for the face-to-face session are listed in Table 2.

The survey results indicate that the main reasons for a student to choose face-to-face are that they like to interact with instructors and classmates and they like to work in the campus computer labs which have better technical support and performance. Among these students, only about half of them have some previous knowledge about the course content, significantly less than those of the online session. A significant finding is that 83% percent of the students have taken other online courses. They come back to take the face-to-face class; this indicates that they are not satisfied with those online courses.

We have followed the same group of students for both sessions for two semesters. The average grades including exam and assignment scores for both sessions have no significant difference by the t-test with the significant level 0.05. About 5.8% of the students in the online session withdrew from the online class while no one withdrew from the face-to-face class. There is a significant change in the enrollment. Initially, 58% of the students enrolled in the online session and 42% of the students enrolled in the face-to-face session. At beginning, some of the students in the online session showed up in the face-to-face session whenever they could attend. On the other hand, some of the students in the face-to-face session used the online computer labs to complete their assignments at home. Now, for the coming semester in Fall 2006, only 16% of the students enrolled in the face-to-face session and 84% of the students registered for the online session. These are the same group students. What has caused such a dramatic change? One thing has to do with the students' confidence towards the online courses supported by the online computer labs. In order to find out how these students' learning

Table 1. Online session survey results

Question	Answer	Percentage
What are your reasons for enrolling in an online class? (Check all that apply.)	Want to have an experience about online classes.	5%
	Online classes do not conflict with my job schedule.	82%
	Online classes allow me to take care of my family.	57%
	The class I preferred was cancelled.	0%
	My preferred class is offered at an inconvenient time.	18%
	Online classes require less study time.	0%
Have you taken an online class before?	No, it is the first time for me.	35%
	Yes, I have taken an online class before.	65%
What is your enrollment status?	Full-time (12 or more credit hours).	18%
	Part-time (less than 12 credit hours)	82%
From where do you log on to the course Web page? (Check all that apply.)	Home computer	100%
	Work computer	53%
	Campus computer	18%
	Public library	0%
What types of Internet connections do you use to access the online course materials? (Check all that apply.)	DSL	29%
	Cable	53%
	Dial-up	5%
	WAN or LAN	29%
What types of operating systems do you use to access the online materials? (Check all that apply.)	Windows XP Professional	94%
	Widows XP Home	29%
	Unix or Linux	5%
	Mac OS	12%
Are you able to handle the following tasks with your computer? (Check all that apply.)	Online chat	100%
	Video conferencing	35%
	VOIP	12%
	VPN	100%
How much do you know about the course content?	Have no knowledge about the course content.	5%
	Have some knowledge about the course content.	89%
	I am familiar with the course content.	6%

Table 2. Face-to-face session survey results

Question	Answer	Percentage of Response
What are your reasons for enrolling in a face-to-face class? (Check all that apply.)	I am not sure about the quality of an online class.	10%
	I did not know there is an online session.	6%
	I do not have a high speed Internet connection.	8%
	I do not have adequate computer equipments.	9%
	I can interact with my instructor and classmates.	83%
	I like to work in a computer lab on campus.	75%
How much do you know about the course content?	Have no knowledge about the course content.	50%
	Have some knowledge about the course content.	50%
	I am familiar with the course content.	0%
Have you taken an online class before?	No, I have not taken an online class before.	17%
	Yes, I have taken an online class before.	83%
What is your enrollment status?	Full-time (12 or more credit hours).	34%
	Part-time (less than 12 credit hours)	66%

behavior changes with time, we need to collect more data from the same group of students over time for longitudinal analysis which will provide us with more convincing conclusions.

6. CONCLUSION

This paper has discussed the issues related to the application of the virtual machine technology in developing online computer labs for hands-on practice. The virtual machine technology can be used to overcome many difficulties in performing hands-on practice online. Virtual machines provide an efficient solution to constructing an online computer lab so that the technology-based courses requiring hands-on practice can be completely taught online. The results of the analysis indicate that the students have gained confidence towards the online lab-based courses, and more and more students on our campuses are in favor of the online courses.

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