

USING MULTIWORLD TECHNOLOGY – VMWARE TO FACILITATE A NETWORKING AND SYSTEMS SOFTWARE LABORATORY

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ABSTRACT

As the emergence of the Information Era continues, courses in information technology have been in high demand in educational institutions nationwide. In the Spring 2001 semester, at Purdue University, a new undergraduate course designed for non-networking majors concentrating on the exploration of network protocols, network operating system fundamentals, network operating systems, and directory services, was offered for the first time. By using VMware as the platform, students were able to gain hands-on laboratory experience that emphasized networking and systems software problem solving and troubleshooting skills through installation and configuration of network operating systems as well as systems software. This paper will describe and discuss the challenges associated with the laboratory activities, teaching, as well as the pros and cons with VMware.

Keywords: VMware, Networking, Operating Systems, Systems Software, Course Development, Curriculum, IT Workforce Shortage, End-User Computing,

INTRODUCTION

US companies are experiencing a severe shortage of information technology (IT) workers. The number of unfilled IT positions at US companies is projected to be approximately 844,000 over the next 12 months (3). Meta Group researchers say there are 400,000 unfilled IT jobs in the U.S., and that figure is expected to balloon to 1 million by 2003 (6). Effects of this challenge may include slowed growth in IT-dependent industries, increased outsourcing overseas, and a decreased supply of technology goods and services.

The Department of Computer and Information Systems Technology (CPT) at Purdue University has a twenty-year history of educating tomorrow's information systems professionals. CPT was created to produce technology and application-oriented graduates who can immediately contribute to a wide variety of information technology projects. Organized within Purdue University's School of Technology, CPT's mission specifically emphasizes teaching and outreach, as opposed to research. This unusual mission and priority uniquely positions CPT to respond more quickly to emerging technologies, like mobile computing, with practical and application-oriented curriculum changes. CPT boasts 700 majors, and serves more than 2,000 non-majors every year. CPT alumni and recruiters time and again point to the department's unique strength in balancing education with technology, business, application, and interpersonal communication. CPT has placed 100% of its graduates into gainful employment over the last five years. Fortune 100 companies and Big 5 consulting firms hire the majority of the students (2).

As the enrollment in the Department of Computer Technology at Purdue University has continued to grow and industry needs have changed the department has a critical need to incorporate more UNIX into the curriculum. This is based on feedback the department has received from numerous recruiters, and The Gartner Group stating students need more hands-on experience with UNIX, network operating systems (N.O.S.) and systems software. In the Spring 2001 semester, at Purdue University, a new undergraduate course, CPT 299S was designed for non-networking majors concentrating on the exploration of network protocols, network operating system fundamentals, network operating systems, and directory services, was offered for the first time. VMware was used as the platform to facilitate the laboratory portion of the course in a production computer laboratory environment.

REVIEW OF LITERATURE

About VMware

VMware is a software company found in 1998. The company's main software product, VMware, is based on the company's patent technology Multiworlds technology, which combines classic virtual machine technology with advanced virtual networking and mainframe-class systems and resource management capabilities (10). "One Machine, Many OSs" (6). VMware lets users run multiple virtual machines on one PC – the host machine, with each virtual machine supporting its own operating system, protocol, and applications. Users can create virtual machines running different operating systems such as Microsoft Disk Operating System (MS-DOS), NetWare, Linux, or any flavor of Microsoft Windows operating systems on a single computer simultaneously. Therefore, users can set up a virtual network, running server and clients on the same box to test new client software without having to worry about wire, switch or hub problems masking client-server incompatibilities (4). Moreover, any errors or crashes in the virtual machines do not affect the physical computer. As of June 2001, the software has more than 750,000 registered users including 5,000 corporate customers in 100 countries (10).

VMware applications in the industry

From the industry perspective, VMware is something of a developer's dream since it capable of hosting both the development and the target environment without the usual confusion and conflicts between the two. Engineers in Marimba Inc. enjoyed running multiple virtual machines on their desktops. They could compare the registry setting between two machines in side-by-side windows and found that they have increased their testing capacity by 70 percent simply by using it in their development and Quality Assurance (QA) desktops (14). SuSE Linux agreed that the use of VMware is especially profitable for developer, technical support engineers, and web developers. A website design can be tested immediately on different browsers and OS combinations. Support engineers can assist their customers faster, in an effective and competent manner, by keeping soft- and hardware combinations on their computers (8). Veritas Software (9) indicated that VMware's server products will address some of the most serious obstacles facing providers of hosted applications and services, especially overcoming the incompatibility of Linux, Windows NT, and Windows 2000; rapid deployment; consolidating servers for greater efficiency and cost-effectiveness; maintaining the stability of existing servers when adding new applications and services; and enhancing security on shared servers. Dell led twenty million

strategic investments in VMware and (13) TurboLinux Japan and VMware joined partnership (12). VMware signed an OEM agreement with Microsoft to offer Microsoft Windows operating systems pre-installed in a virtual machine. Other companies, such as IBM, HP, SAP, and Google work closely with VMware. Overall, VMware is favorable to industrial vendors and developers of different platforms and scales.

VMware applications in government

National Security Agency (NSA) teamed up with VMware to build advanced secure computer systems. By using the software, government users are able to safely use commercial off-the-self software for certain sensitive or classified applications and environments. The “VMware’s technology already provides high level of security,” said by Mendel Rosenblum, chief scientist in NSA (11).

VMware applications in education institutions

While VMware is gaining positive feedbacks from industry and government, some educational institutions have also tried to choose VMware in support of course development. Clemson University has a VMware pilot project where it runs VMware for the management of all desktops. When students login to their environment, it is a virtual machine on a central server. Students may be reconfigured under a different operating system or with different applications without needing a system administrator visiting their desktop to make changes (1). Professor Nieh and Ozgur of Columbia University have been using VMware as the tools in their operating-system courses (5). They installed VMware on university servers for 140 students to experiment making operating system changes without crashing the university network and machines. Each student uses a separate virtual machine session on a server. Also, the virtual machines are isolated from both the server and network. Nieh and Ozgur found that students’ experiences with VMware were quite positive, easy, and intuitive to use (5).

LAB DEVELOPMENTS AND CONTENTS

The laboratory portion of the course in CPT provides students a means of gaining hands-on experience of installation and configuring network operating systems and systems software. The class size in the Spring 2001 semester was 22 students with the majority being seniors. Students were grouped into 6 groups of 3-4 students. The laboratory section of the course consists of seven projects: a two-week exercise on Windows NT 4.0 Workstation and Server, a two-week exercise on Windows 2000 Professional and Server, a three-week exercise on Microsoft Exchange 2000, a two-week exercise on Microsoft SQL Server 2000, a two-week exercise on Microsoft Commerce 2000, and a three-week laboratory on both Red Hat Linux 6.2 and Apache Web Server. For example, the objectives for the Windows 2000 Server and Professional projects are as follows:

Primary Objectives

- Install network operating system (Windows 2000 Server)
- Update the NOS with Windows 2000 Service Pack 1

- Configure networking on the NOS to support the default network and transport layer protocols (TCP/IP)
- Install and configure Active Directory Services
- Configure the NOS to share resources
- Set up administrative permissions for shared files and folders
- Create and configure network users with Active Directory Services
- Create user Home Directory and implement appropriate security (i.e. Only Administrators, System and the specific user can have the full control of user's Home Directory)
- Grant user rights to shared resources
- Install the following client operating systems and configure them to access shared resources from the server NOS: Windows 2000 Professional
- Install and configure a print server on the Windows 2000 Server
- Use LPT1 as the Printer Port
- Select a the printer
- Create a Spool directory
- Share the printer and grant permissions to users
- Add a network printer on the Windows 2000 Professional

Secondary Objectives

- Implement connectivity between your server and another server running Windows NT 4.0
- Install applications to the server and configure the clients to run the applications from the server (i.e. MS office)

LAB SETTINGS

Hardware and software settings in the laboratory

The computer laboratory and network were provided and maintained by the Technology Computer Network (TCN). The production laboratory used for this course included 25 workstations: Dell Precision Workstation 220 with Intel Pentium III 667 MHz and 512MB RIMMs PC-600. Each machine had a 10GB, 7200-RPM and ATA-66 local hard disk and ran Microsoft Windows NT 4.0 Workstation. Each student group could use up to 3 machines, but students mostly used only one machine at a time to create multiple virtual machines on the host machine. VMware workstation version 2.03 had been preinstalled on each workstation. Students were provided with tutorials to configure virtual machines.

Each virtual machine shares the hardware resource with the host machine. The VMware memory configuration options determine the amount of host system memory that each virtual machine is allowed to use. Students assigned 128MB and 192MB for workstation and server virtual machines respectively. The disk configuration options in VMware determine how disk partitions mounted by the host OS are used to export a virtual storage device to the guest OS. Students configured virtual disk with size of 2GB. A virtual disk in VMware is simply a large file in the

host OS file system that is treated by the virtual machine as an IDE disk. However, instead of storing the virtual disks on local host machines, all virtual disks were stored on a network-attached storage (NAS) device in the network. In this way, students could log on any of those 25 workstations and work on their projects whenever any of the workstations were available. Similarly, the CD-ROMs of operating systems and software were also located on the NAS, students needed to configure the host machine and the settings for each virtual machine before using each CD-ROM.

Network settings for the laboratory

The network-attached storage (NAS) device was actually a Dell PowerEdge 2400 server with 2 Pentium III processors and 512MB RAM. The capacity of the NAS was 219GB with a RAID-5 setting. The NAS server was connected to a Cisco router via two 100Mbps connections, which in turn was configured in 400Mbps Full Duplex Etherchannel with the main switch in the building. The 25 workstations were connected via 100Mbps Full Duplex to a switch in the computer room, which in turn was connected via a 400Mbps Full Duplex Etherchannel to the main switch in the building.

PROS AND CONS WITH VMWARE

Benefits of VMware

The main benefits of VMware in the course were: cost effectiveness, space saving, and portability. Without heavy investments in hardware and additional space, students could create a network on one host machine in a production computer laboratory environment. Since the virtual disk images were stored on a network-attached device, students could start virtual machines on any available workstation in the laboratory.

Performance issues with VMware

Students and instructors faced some performance issues when using VMware in the laboratory. Latency caused extensive time to start up a virtual machine and installation time, bad mouse and keyboard control. According to the evaluation survey at the end of the semester, students were mostly concerned about the long delay or response time in the virtual machine, and the bad control of the mouse and keyboard. They had to wait more than 20 minutes to start up a virtual machine, especially running Windows.

CHALLENGES WITH VMWARE

Concepts of virtual machine

The first challenge in the laboratory portion of this course was the concept of virtual machines, and the use of VMware. At the beginning, without adequate experience with networking and hardware, it was not straightforward for students to distinguish the difference between the host machine and the virtual machine, the host OS and the guest OS. To ensure students understood

the concepts about VMware, instructors spent two laboratory meetings explaining VMware with diagrams and demonstrations.

Knowledge of DOS

Since CD-ROMs were created as virtual disks and only accessible through the network-attached storage (NAS) device students needed to mount the partition located in NAS to the host machine, and then configure those CD-ROMs as virtual disks in VMware configuration options. In order to start an installation of any Windows operating system, a virtual machine needed to be started with a DOS floppy image. New virtual disks were required to be partitioned and formatted. Students should have some basic knowledge about DOS commands. DOS was thus introduced and demonstrated to students during the first two meetings.

Demonstrations and Tutorials

Due to the performance issues with VMware, such as unstable response time and bad mouse control, instructors could not efficiently demonstrate any installation and configuration of operating systems and systems software. Therefore, instructors developed tutorials on the course website. Students could follow the step-by-step instructions with screenshots to complete the project. In addition, the course website also included links to vendors' websites and other discussion forums about operating systems and software. This provided a means of troubleshooting problems in the projects and exploring additional topics.

CONCLUSIONS

According to the evaluation survey, most students felt comfortable with the topics covered in the laboratory. They also indicated that they would like to know more about Unix/Linux and DOS. In fact, the laboratory contents will be constantly changed due to the advance of new technologies, such as upgraded versions of operating systems and software. Based on recommendations, majors in Information Systems should know more about database engines and web servers. Some topics can be extended to cover concepts in more depth, such as DOS, Windows 2000, Unix/Linux, MySQL, etc.

Performance issues with VMware in the laboratory are necessary for further research. It will be invaluable to compare the difference between storing a virtual disk on a local host machine and on the network. There can be a significant difference while using different operating systems (Linux vs. Windows) on the host machine. There may be better network topologies or other enabling technologies that can improve performance.

During the Fall 2001 semester the students in CPT 299S will concentrate more on NOS and protocols. The tentative schedule includes two-weeks on DOS/VMware orientation, four-weeks on Windows 2000 Professional and Server, four-weeks on Microsoft BackOffice, concentrating on SQL Server 2000 and Internet Information Server (IIS). Students will finish the last five-weeks of the semester covering Linux, Apache Web Server, and MySQL. Concerning the performance issues, some of the objectives that require extensive processing power will be minimized. The current network infrastructure and the configurations for virtual machines will be optimized to enhance the applications with VMware.

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