The Role of Operating Systems and Network Administration in the IS Curriculum

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Abstract

The reliance by companies of all sizes on information technology creates strong demand for system and network administration jobs. Information System majors will increasingly find themselves with opportunities and responsibilities in these areas. However, teaching operating systems and networking to information systems major presents many challenges. We have developed a model for teaching these topics to information systems majors in the context of operating system and network administration. This paper describes our model, the lecture materials used, and a novel lab configuration.

Keywords: administration, education, operating systems, networking

1. INTRODUCTION

Networks of computers are *the* model for business information infrastructures today. Gone are the days of a single mainframe machine with terminals attached to it. Today, a business' information infrastructure consists of one or more servers that communicate with tens, hundreds, and even thousands of clients, and the explosive growth of networks drives an increasing demand for network administrators. Exceptional growth in IT jobs, including network and system administration, is widely expected to continue for the foreseeable future. Reports from the Commerce Department cite a shortage of high tech workers. The White House has recently created training programs to address the shortage. While some organizations and researchers dispute the extent of a shortage, it is widely agreed even by critics of such studies that new IT jobs are being created very rapidly. As information technology becomes ubiquitous, and even very small companies rely on it for their daily operation, the skills of system and network administration become more in demand, and more vital. More and more IS majors may find their future job responsibilities including some system administration duties, even if they are not hired strictly in that role.

A network administrator is a manager: not of people but of computing resources. A network administrator is responsible for installing new hardware and software, creating and managing user accounts, installing and maintaining print services, ensuring that the network is running smoothly and that the computers are communicating efficiently, verifying the integrity (security) of the network, handling user complaints, and so forth.

Traditionally, the role of network administrator has been filled by computer science (CS) graduates, but not because they receive special training for that position. Network administration lacks a traditional academic home - you will rarely find a network administration course at a college or university. Yet, CS students seem to fill the position of network administrator because as students computer scientists gain a fundamental theoretical knowledge of operating systems and networks. A typical CS student has an understanding of processes, distributed services, networking protocols, file systems, network topologies, etc. This fundamental knowledge enables a CS student to learn the high-level managerial aspects required of a network administrator. However, the role of network administrator is suited more to an information systems (IS) graduate than a computer science graduate. Information/computer management issues are the raison-d'être of information systems.

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The current publicly available reference for IS curriculum describes the topics of networking and operating systems in two courses (Davis 1997; Longenecker 2000)**Error! Reference source not found.**. The relevant parts of those course descriptions are excerpted below.

> IS '97.4 Information Technology Hardware and Software: "operating systems functions and types; operating system modules: processes, process management, memory and file system management, ... basic network components, ... installation and configuration of multiuser operating systems."
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> IS '97.6 Networks and Telecommunication: "in-depth knowledge of data communications and networking requirements... Students learn to evaluate, select, and implement different communication options within an organization... architectures, topologies and protocols; installation and operation of [network devices], ... network performance analysis; privacy, security, reliability ... installation and configuration of LAN and WAN networks; monitoring of networks"

Although the current curriculum standard suggests two courses, we feel that in the context of administration, operating systems and networking should be taught in a single course. We justify a single course by the fact that modern operating systems are tightly coupled with networking, and that administration of a "computer system" involves both operating system and networking issues.

We have developed a course consistent with the current curriculum standards, while at the same time raising the profile of the role of IS majors in system and network administration. Our course teaches the fundamental principles of operating systems and networks, but with a decidedly information systems slant. The course is a marriage of traditional computer science theory with practical hands-on experience.

With this paper, we hope to achieve several goals. First, we hope to raise awareness of the need for network administration. Second, we hope to demonstrate the need for an academic course in administration. Third, we wish to show that system administration is a topic well-suited to information systems. Fourth, we hope to provide a pedagogical model for others to follow in developing a course in operating system and network administration.

The rest of this paper describes our course goals and structure, then presents our ideas and experiences in teaching it.

2. COURSE GOALS

The basic goal of the course is to teach IS students problem solving/administration skills in operating systems and networks. After having taken the course, students should be able to set up and maintain a network of machines and computer services. Specifically, the course has two complementary goals. First, students should get a solid foundation in the fundamental theories and models of operating systems and networks. However, unlike a traditional CS operating system or networking course, our IS-centered course lacks many of the low-level details. For example, rather than teaching a topic like virtual memory by describing page tables, table lookup buffers, paging algorithms, etc., the topic is taught in the context of swap space, and swap space management.

The second goal of the course is to provide students practical hands-on experience administering an actual system**Error! Reference source not found.**. This is unlike the industrial training model that teaches specific applications and products (e.g., Microsoft Certified Engineer program, or Novell certification) without a solid grounding in fundamentals.

3. COURSE IMPLEMENTATION

Grand Valley State University is a growing suburban university with approximately 17,000 students. GVSU is primarily an undergraduate institution with a handful of master's programs, and like other schools in the same category, most of our graduates do not continue their education into graduate school. Our department is a joint Computer Science/Information Systems department consisting of 16 faculty members. This creates an ideal environment in which to teach a course that borders between the classical CS and IS curricula, and to share lab resources.

Information System majors at GVSU take two courses in the systems area. The first, CS 337 Network System Management, covers the lower layers of the protocol stack (physical and data-link), with an emphasis on LAN technology and network operating systems administration (Novell and Windows NT). Students complete a major project where they analyze, design, and specify a LAN infrastructure for a fictitious company. The second course, CS 437 Computer Systems Management, is the topic of this paper. CS 437 is taken after CS 337, and covers the higher layers of the protocol stack (network layer and up), in addition to foundational concepts of operating systems (e.g. storage, memory, CPU cycles).

Methodology

The course is divided into two integrated components: lecture and lab. Lecture is used to teach ideas, fundamentals, and theory, while lab is used to provide practical experience. The purpose of the lecture portion of the course is to teach the fundamental knowledge of operating systems and networking in the context of administering a network of computers. The role of the lecturer is to describe some aspect of OS or networking theory and then demonstrate how that theory is applied to a modern operating system or network. The teaching of theory is further enhanced by using real-world examples related to administration. For example, in order to teach the concepts of process management, the lecturer would describe what a process is, what resources a process uses (disk, CPU, memory), how processes are created, how processed are killed, etc. These concepts are strengthened by showing the students how resources are allocated when a process is created; how resources are freed when a process dies; how to determine if a process uses an excessive amount of resources; how to kill a process if it gets out of hand; etc. Thus, not only are students learning the critical areas of operating systems and networks, but the knowledge is reinforced by practical hands-on exercises.

Lecture and Lab Material

The lecture component of the course is divided into two sections. The first half of the course covers operating systems, the second half of the course covers networking. The purpose of the lab component of the course is to reinforce topics covered in lecture and to give students hands-on experience with administrative tasks. The lecture and lab are complimentary. Lecture material typically covers the theory behind some concept, while the lab addresses the same material from a pragmatic standpoint. The relevant parts of the course syllabus are given below.

CS 437: Computer Systems Management

Course Description: This course provides a foundation of operating system and networking concepts for the IS majors in the context of modern networked computing environments. It also continues the study of the networking protocol stack started in CS 337. From this foundation we study the protocols, technology, and design issues of computer systems management. For both networking and operating systems, the perspective of the course is that of the system administrator. Laboratory experience with Linux and TCP/IP is an integral part of the course.

Course Objectives:

- Learn the fundamentals of an operating system as they are relevant to the system administrator.
- Complete the study of the network protocol stack, specifically the network, transport and application layers.
- Develop an understanding of the relationship between a computer, a program, the network, and the operating system.

Texts:

- *Computer Networks, 3rd Edition.* Andrew Tanenbaum, Prentice-Hall, 1995. (continuation of text from CS 337)
- *Essential System Administration, 2nd Edition* Aeleen Frisch, O'Reilly & Associates, 1995.
- *TCP/IP Network Administration, 2nd Edition* Craig Hunt, O'Reilly & Associates, 1998.

Course Schedule:

In a 14 week course, we cover the following topics:

- Introduction to UNIX: Files, Processes, Devices, UNIX Tools (2 weeks)
- Shell Scripts and Perl (1 week)
- Boot Process and OS Initialization (1 week)
- Managing Users and Groups of Users (1 week)
- Managing the CPU, Memory, and Filesystems (2 weeks)
- Network Protocol Stack and Application Layer: DNS, SMTP, and HTTP (2 weeks)
- Transport Layer (1 week)
- Network Layer (1 week)
- Network Configuration (1 week)
- Configuring a Server (1 week)
- Security (1 week)

Lab Structure

The lab itself consists of 24 400MHz Pentium machines running the Linux operating system (RedHat 6.1). Each machine has 128MB of RAM, 6GB hard disk, 3.5" floppy, and a 100MB ZIP disk. The lab is a production lab available to all CS and IS students. Many of them use the lab as their primary account on campus. Because the lab is not a dedicated teaching lab, giving all CS 437 students superuser access is out of the question. However, students *must* have superuser access in order to do even the most basic administrative tasks.

To overcome this problem, students use the ZIP disk as their primary file system. Each student has their own ZIP disk on which they install a slimmed-down version of Slackware Linux (RedHat is not used because of the difficulty of creating a minimal installation able to fit in 100MB.). The Slackware distribution contains all the files and utilities required to do a wide variety of administrative functions - installing users, configuring network interfaces, modifying system configuration files, etc. They use a custom-built kernel that disables all access to the hard drive, preventing them from booting their ZIP disk and mounting the hard drive as the superuser. Keeping the students isolated on their own ZIP disk has proven to be a convenient, robust, and safe way to provide superuser access while ensuring that the production lab remains uncompromized. Other researchers have commented on the unreliability of the ZIP drive (Drake 1997; Mayo 1999; Smith 1997), but we have not encountered any problems.

A typical lab session involves the following. First, students insert the ZIP disk and a boot floppy containing the Linux kernel. The student reboots the machine and logs into their system as "superuser". The student then performs the administrative tasks for that lab. After performing the lab activities for that day, the student simply removes the ZIP and floppy disks and reboots the machine. After booting the machine is restored to its production state.

We chose to use Linux for several reasons. First, most of our IS students have not used any operating system other than Windows. Using Linux in our class gives students experience with another major operating system. Second, although administrative GUIs exist for Linux, we chose to use the command-line interface. Using the command-line reinforces the ideas behind topics, rather than teaching students how to use a particular GUI. A non-GUI approach is not feasible in Windows. Third, Linux is easily customized to provide a secure environment in which students can work. For example, we have customized the kernel so access to the hard disk is forbidden. Fourth, a fully-functional Linux distribution can fit in 100MB.

4. CONCLUSIONS

As companies demand more system and network administrators IS majors will increasingly find themselves with new opportunities and responsibilities. Thus, the need exists to teaching operating system and network administration to IS students.

We have taught this course to IS majors over the last two semesters. Overall, the students seem genuinely interested in the subject. They understand the importance of network administration, and many of them appreciate the importance that Linux will play in the future of computing. Some students, usually those brought up in a Windows environment, will sometimes ask about a GUI interface. We emphasize that the course is about teaching fundamentals, and that fundamentals apply everywhere regardless of what kind of user interface you have.

The mixture of lecture and lab has been a success. The lab material helps to strengthen the ideas talked about in lecture, and permit the student to apply that knowledge in a meaningful way. We feel that knowledge application (especially in the area of network administration) is crucial in the learning process.

Finally, the lab environment itself, and especially the use of ZIP drives, has been crucial in allowing users to gain access to administrative functions without compromising the integrity of a production lab.

5. REFERENCES

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