Teaching TCP/IP Networking Using Practical Laboratory Exercises

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ABSTRACT

It is often difficult to motivate students to learn TCP/IP networking concepts because students appear to find the subject rather technical, dry, and boring. To overcome this problem, we have prepared some practical laboratory exercises (practicals) and other materials. They are designed around a multi-user, multi-tasking operating system and are suitable for classroom use in undergraduate TCP/IP networking courses. The effectiveness of these practicals has been evaluated both formally by students and informally in discussion within the teaching team. The implementation of the practicals was judged to be successful because of the positive student feedback and because students improved their test results. This article describes the practicals and their impact on student learning and comprehension, based on the author's experiences in an undergraduate IT course.

Keywords: computer education; evaluation; FTP; IP subnetting; Linux; TCP/IP networking

INTRODUCTION

Transmission Control Protocol/Internet Protocol (TCP/IP) is often included in computer science, engineering, information technology, and business courses, as TCP/IP is a fundamental component of Internet protocol suite. Unfortunately, motivating students to learn TCP/IP networking fundamentals is often difficult, because they find the subject is full of rather dry and boring technical jargon. However, the view frequently is supported in the educational literature (Anderson, Reder, & Simon, 1996; Young, 1993) that incorporating practical demonstrations into these courses, thereby illustrating theoretical concepts and providing opportunity for hands-on learning experiences, significantly enhances student learning of TCP/IP networking concepts. Yet, despite the Chinese adage attributed to Confucius (551–479 B.C.), "I hear, I know. I see, I remember. I do, I understand," only a limited amount of material designed to supplement the teaching of TCP/IP net-

working is publicly available, as searches of the Computer Science Teaching Center Web site (http://www.cstc.org/) and Special Interest Group in Computer Science Education (SIGCSE) links page (http://sigcse.org.topics) reveal. Therefore, we have prepared some practicals that facilitate an interactive, hands-on learning experience in TCP/IP networking. These practicals are designed around Redhat Linux (version 8), and can be used either in the classroom as a demonstration to enhance the lecture environment or in the computer laboratory to provide hands-on learning experience at an introductory level (either first- year or second-year undergraduate courses).

We strongly believe, as do many others (Abe et al., 2004; Cannon, 2003; Casado & McKeown, 2005; Leva, 2003; Midkiff, 2005; Sarkar & Craig, 2006), that students learn more effectively from courses that provide active involvement in hands-on learning activities. Students gain first-hand experiences in TCP/IP networking by hands-on practical work (e.g., setting up a TCP/IP network, installing and configuring a server, IP subnet addressing, TCP/IP connectivity, Telnet, anonymous FTP, name resolution, etc.).

The basic concept of TCP/IP networking is described in many textbooks (Forouzan, 2003; Kurose & Ross, 2005; Mansfield, 2003; Raymond, 2005), and IP network performance is discussed extensively in the networking literature (Gotsis, Goudos, & Sahalos, 2005; Hassan & Jain, 2004). Sloan (2004) describes TCP/IP lab materials that may be suitable for practical work in the laboratory. However, these lab materials are still a work in progress. A number of sophisticated network simulators exists for building a variety of TCP/IP network models (Fall & Varadhan, 2003; OPNET, 2004; Zeng, Bagrodia, & Gerla, 1998).

Nevertheless, by setting up and configuring actual TCP/IP networks, the students gain first-hand experience that cannot be gained through computer simulation and modeling. To date, we have focused on developing practicals in order to support teaching and learning traditional TCP/IP networking courses at undergraduate level (second year). The hands-on learning approach to teaching TCP/IP networking has been applied successfully for two years now in the networking and telecommunications course (undergraduate IT curriculum) at AUT University. The course covers the main aspects of TCP/IP networking, including client-server networking, local-area network (LAN) administration, and management. The practicals and other materials are revised annually based on student feedback, and the use of the latest version is discussed in this article.

The main contribution and strength of this article is the emphasis that practical experience with hardware and a multi-user operating system is crucial to effective student learning. The most innovative aspect of this work is the structuring of the laboratories and crafting of the specific exercises to be effective in complementing the lecture content of the course. The course context in which the practicals are presented is described next.

Course Context and Learning Outcomes

The course networking and telecommunications in which the aforementioned practicals are introduced have a total of 56 contact hours assigned. This course is at Level 6, or second-year degree level (one quarter of a full semester's course of study) at AUT University (Sarkar & Clear, 2000; Sarkar & Petrova, 2001). The Level 5 hardware and software infrastructure is

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