

# Computer Network Management: Theory and Practice<sup>1</sup>

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## 1. Abstract

This paper discusses a non-traditional course in computer networking. The course is a laboratory course with substantial hands-on experiences, which can help to prepare students for jobs in industry as soon as they graduate from an undergraduate institution. This course is not meant to replace the traditional network course but to supplement it by teaching how computer networks work in practice and by exploring new topics such as internetworking, high speed networking, client/server computing and security.

### 1.1 Keywords

network, course, undergraduate, practical

## 2. Introduction

The area of computer networks is very broad and growing larger every day. Typical undergraduate courses in the field only address the basic principles of computer networks and do not have the scope to cover internetworking, security, client/server computing and high-speed networks. Additionally, the first course give little or no experience setting up and maintaining a real computer network, and thus does little to prepare students for jobs directly out of undergraduate school. This paper discusses a second course in networking from the system administrator point of view. The course addresses some of the deficiencies of the first course and attempts to better prepare students for jobs and graduate work.

## 3. Background

The host institution is a primarily undergraduate commuter

college where 90% of the students work 20 or more hours per week to pay for schooling. Approximately 90% percent of graduates seek employment from local industry directly upon graduation. The computer science program is recently accredited and hosts about 400 majors supported by 12 faculty members. The host institution supports 10 computer labs containing mostly Intel based computers with about 40 UNIX machines and 20 Macintoshes. These labs are fully networked and reside in several buildings connected by a fiber backbone.

The required semester long network course follows the "Computer Networks" text by Peterson and Davie [5], and covers the seven layer OSI model, TCP/IP, communication media, encoding, error correction and detection, ARQ protocols, routing algorithms, and congestion control. There are typically two to three computer projects including some network simulation, some work with protocols and some client/server computing using sockets.

Automobile and parts manufacturers dominate local industry. These companies and others are in need of qualified system administrators. The dominate platform is Intel based computers running the NT operating system but which are required to communicate to UNIX and Macintosh computers. The automobile manufactures have some need for high performance computing for CAM. However, they have for the most part eliminated many of their mainframes and now have a vast number of lower end computers networked together. The automobile industry is expanding it's networking demands by having sales and inventory on-line and by experimenting with in-house training over the network.

The BellSouth conference and other publications [2,3] called attention to the importance of computer networks at both the undergraduate and graduate levels as well the need for laboratories and course work. Similarly the NSF report on networking and communications [6] expressed "an urgent need for educational programs to keep up with the rapid advances that have occurred in this area." Several universities have begun work on a telecommunications suite of courses at both the undergraduate and graduate level [1].

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Due to the premium paid by industry, student enthusiasm for the computer network courses is very high. The course described in this paper also serves as an excellent course for students who are weaker in mathematics. Finally, the course is popular among students who are curious about the actual mechanics of computers and networks as well as those who are excited about high speed networks and applications.

#### **4. The Laboratory**

Although the host institution is very fortunate to have had the laboratory partially funded through a NSF-ILI grant. A less cutting-edge laboratory can be constructed for only a moderate amount of money (on the order of \$20,000 plus computers). The laboratory consists of 16 Pentium II computers, running Windows NT, connected by twisted pair cable. The computers can be connected by either 10/100 Mbs hubs, a 100 Mbs switch, or by a fiber connection to an ATM switch. The laboratory has both an Ethernet connection to the campus server as well as a phone jack. The laboratory is shared by several classes. Removable hard drives were purchased so that work done by students in this course has a minimal effect on the other classes. The laboratory is also used to support a suite of Microsoft Certification courses, which generates revenue to keep the lab current.

Additional equipment that can be borrowed, includes raw twisted pair cable, a cable crimping tool and analyzer, a Macintosh, a Unix machine, a network printer, some old external modems and an old campus router. Some of these items are only in the network lab for the week in which they are studied. Software needed for the course include: Windows NT server software, a traffic analyzer, a proxy server, a firewall package and a Domain Name Server. Several items such as the proxy server and firewall software can be downloaded free from the Internet.

#### **5. The Course**

The course is roughly divided into NT administration for the first 9 weeks and selected topics for the remainder of the semester. Although the course focuses on NT administration, the instructor attempts to emphasize the administration tasks that are platform independent. Topics include: NT overview, LAN, Configurations, protocols, hardware, clients, installation, domains, users and groups, shared file management, printers, monitoring, UNIX, Macintosh, modem connections, Domain Name Service, email, the internet, routing, switching, video, ATM, analysis, benchmarking, and Novell Netware.

Each ninety-minute class features approximately twenty-minute of lecture on the topic of the day, followed by a laboratory exercise that puts into practice the concepts previously discussed. Student's grades are computed by evaluation of their laboratory reports, some homework exercises, a midterm and an oral presentation on a cutting edge aspect of computer networks. Students typically work

in teams of 2 for most labs, but work in groups of 4 and 8 when there is not enough equipment to go around.

The primary text is "Hands on Microsoft Windows NT 4.0 Server with Projects" [4] and is supplemented from a wide variety of material found in other texts and on the Internet.

#### **5.1 Laboratory exercises**

##### **Week 1**

Lecture on an overview of NT as compared to Novell, and UNIX networks. Overview of the laboratory equipment and laboratory rules. In the laboratory, students perform a remote installation of both server and client machines (using generic settings). For most experiments, all but one computer (the primary) is setup as a secondary server. However in the beginning of the course, students deal with single computer networks and make clients out of neighboring machines.

##### **Week 2**

Lecture on hard drives, memory and cables. This lecture compares various types of components as to functionality, current prices and current trends. In the laboratory, students remove and install hard drives, memory as well as create and test twisted pair cable.

##### **Week 3.**

Lecture on various LAN configurations and protocols. In the laboratory, students experiment with various protocols and layouts of the network.

##### **Week 4**

Lecture on server functions, administration tools and administration duties. In the laboratory, students configure servers and clients as well as create users, groups and assign rights to these groups.

##### **Week 5**

Lecture on domains, relationships and directories. In the laboratory, students set up domains and experiment with access to various domains available with different configurations.

##### **Week 6**

Lecture on adding shared devices (printers, modems etc.) and connections to non-NT networks. In the laboratory, students add various printers and modems. Students also connect the Macintosh and Unix station to their network.

##### **Week 7**

Lecture on monitoring system performance and status. In the laboratory, students simulate activities and analyze the performance of users, memory usage, traffic volume and patterns, and CPU usage. Students also generate statistics, which will be used later when ATM and switched networks are studied. These statistics will also be used to help tune the network.

## Week 8

Lecture on various maintenance jobs and techniques. In the lab, students perform various backups using automatic tape and a redundant array of inexpensive disks (RAID).

## Week 9

The class reviews for ninety minutes and then spends another ninety minutes taking a closed book and a practical examination. The practical part of the exam has students do simple administrator functions as well as one trouble shooting exercise.

## Week 10

Lecture on bridges and routing. In the laboratory, the class experiments with configuring and measuring performance of the router.

## Week 11

Lecture on ATM and LANE. In the laboratory, students set up and experiment with ATM.

## Week 12

Lecture on setting up a domain name server (DNS). In the laboratory, students set up a DNS server and create an email and web server.

## Week 13

Lecture on point to point protocol (PPP) and compression techniques. In the laboratory, the class set up a PPP server and experimented with sending video over the network.

## Week 14

Lecture on security issues. In the laboratory, set up and experiment with proxy servers and firewalls.

## Week 15

Lecture on Novell. Students set up Novell network.

## Week 16

Student presentations on new developments in computer networks. Past topics have included: gigabit ethernet, cable modems, phone calls on the internet, internet ethics and copyright law, compression techniques, and game playing on the internet.

In several of the experiments students must find, diagnose and fix a problem placed in their equipment. These problems are based on actual problems encountered by system administrators at the institution and in local industry. Additionally, the class occasionally has the opportunity to take "field trips" to help out the campus system administrators when non-security related problems arise or when new equipment needs installation.

## 6. Suggestions for Other Institutions

The course is easily adaptable to other institutions. The high cost items in the course include: the ATM switch, the Ethernet switch and the router. These items can be borrowed, replaced or simulated with shareware software in

the course. There are many topics such as security and distributed databases, which can added or enhanced to customize the course to the equipment available and the interest of faculty, students and local industry. For example, the use of Windows NT can easily be replaced by another networking system.

Institutional support is very high for the course since it generates a pool of qualified students who can administer the campus network at low cost. Care should be taken in using analysis tools since many tools can be used to gain illegal entry into accounts. The class is removed from the campus network when these exercises are performed.

## 7. Conclusions

The course has been very popular with students, local industry and the campus administration. Student reaction has been very positive and comments such as "at last a course that will help me get a good job" are common. Local industry also has positive comments on the course and is investigating ways to allow employees to take the course over the Internet. Campus administration is pleased with the opportunity to get more qualified help to run the campus network, as well as the extra revenue generated by the Microsoft Certification courses. The described course has become a regular offering at the host institution and if the current high demand continues, will be offered twice a year. Some laboratories and lectures are now available on at my web site, however these are still preliminary.

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