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Teaching Tip

Telecommunications and Data Networking Course: Balancing Theory and Practice

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ABSTRACT

This teaching tip addresses the faculty preparation, course design, and resource allocation undertaken to teach an undergraduate course in telecommunications and data networking to business students with a concentration in Information Systems. There are special difficulties in designing such a course because of the hardware preparation involved and the assignment of supervisor rights to a large number of students. The course lectures are integrated with problem-solving oriented laboratory based assignments. The author believes that hands-on experience with networking hardware and software for the students is essential to grasp the data networking concepts.

Keywords: Data networking, information systems education, telecommunications

1. INTRODUCTION

Telecommunications and data networking have been of strategic importance within the overall information systems architecture of business world. With the ever-increasing access to the Internet, there has been an exponential growth in both wired and wireless networks. Hence, a need to understand fundamental telecommunications and data networking concepts with a pragmatic approach to networking is critical for business students. This teaching tip describes the author's experience in the design and implementation of a Telecommunications and Data Networking course. Almost every Management Information Systems department at the California State University now offers a one to two courses in Telecommunications and Data Networking.

2. COURSE DESIGN PHILOSOPHY AND CONTENT

Most of the senior business students with a concentration in Information Systems (IS) are expected to have basic knowledge of computer (PC) hardware and operating systems (OS). Further more, these IS students have taken classes in Visual Basic, Database design, System Analysis, and Probability and Statistics. Therefore, a challenging problem is to deliver the technical concepts in a framework so that the IS students can synthesize all the details contained in a Telecommunications and Data Networking course.

A business graduate in Information Systems with a practical knowledge of data networking and a clearer appreciation of the Open Systems Interconnection (OSI) network model should meet the entry level requirements in the Information Technology section of most corporations. The learning objectives are primarily derived from the OSI model, and incorporated in the course. Hence, the lectures would focus on practical considerations given to planning, designing, and building a Local Area Network to support Information Systems.

2.1 Course Objectives

1. Given a typical configuration of a company's data network, describe the data flow through this network, including all the key events that occur at Layer-1 through Layer-3 of the OSI model.
2. Use a floor plan of an organization's office(s), indicating departments and general networking needs, design a network for the office specifying computers, topology, network hardware, and cabling system.
3. Given the design of a Local Area Network (LAN), evaluate and recommend two to three workable alternatives for segmenting that LAN to improve performance.

4. Specify the Information Systems Architecture to be supported by the network, and the Network Operating System (NOS).

2.2 Textbook

The following four textbooks on Telecommunications and Data Networking (Forouzan, 2002; Fitzgerald, 2002; Panko, 2002; Stallings, 2001) were reviewed by the author. The selection of the textbook for the course was based on the following criteria.

- The order, in which the chapters are presented, should follow the OSI model, beginning with the Physical Layer and ending with the Application Layer.
- The concepts should be presented with some what technical details; since the intended audience is IS majors.
- Each chapter should end with a case study that provides an opportunity to apply technical and management concepts.

The author selected a textbook that was easy to read and follow, and satisfied the above criteria (Fitzgerald, 2002).

2.3 Lectures

Two hours of lectures per week was assigned to the course. Lectures were planned and prepared from the perspective that data networks are designed and implemented to meet clearly defined business objectives by supporting applications and data, which in turn, support the critical business functions of a corporation. The author believes that the role of a teacher is to help students build a knowledge base instead of presenting to them a particular set of knowledge. Therefore, simply discussing the concepts does not necessarily lead to a student developing intuition into the key issues. So the author's teaching strategy was to introduce concepts from data communications, and then relate it to real-world examples where businesses had successfully integrated the technology and made gainful advantage over the competition. When discussing Wide Area Networking (WAN) technologies, the author would present an example of a business with three locations, a given budget, and the bandwidth requirements to design a WAN to interconnect the three LANs at each of the three locations. The choices in technologies are an Analog modem, a Cable or Digital Subscriber Line (DSL) modem, using Public Switched Telephone Network (PSTN) or a Data Service Unit (DSU) with T1 lines (digital).

3. LABORATORY DESIGN PHILOSOPHY AND CONTENT

The author procured a set of routers, Layer-2 switches, hubs, Category (CAT) 5 cables, two mini-racks, a set of patch panels, and fourteen PCs. Two LANs were set up in the laboratory. Each of the LAN had a group of six computers connected to a 10/100 Mbps configurable switch. Each of the two switches in the LANs was then connected using a multi-mode fiber to another 100 Mbps backbone switch to demonstrate a backbone network design. This backbone switch has two servers connected to it. Each of the servers has the following network operating system installed: LINUX and Windows 2000 server. The purpose of using different Network Operating Systems is to demonstrate internetworking among proprietary network protocols that make up Enterprise Networks. Each LAN was segmented on the basis of IP network address, thus demonstrating a need for routing traffic between different IP segments. Additionally, each router is equipped with a 56Kbps Data Service Unit (DSU) module to provide a link to FT1 (Fractional T1) data-line. The rationale behind building a data network on a smaller scale was to illustrate the following principles.

3.1 Demonstrate Ethernet (Layer-2) Segments

A LAN is designed with segmented architecture to maximize the available bandwidth for the network users. A Layer-2 device such as a switch is used to build micro-segments to reduce the number of data frame collisions due to the broadcast nature of the Ethernet protocol. Computers are connected to a patch panel, which is mounted on a rack. Patch cables are used to patch the connection from the patch panel to either a switch or a hub. This demonstrates the principles of modular design of data networks.

3.2 Demonstrate network (Layer-3) segments using the Internet Protocol (IP)

Every corporate IP network is designed using IP address scheme. This design feature of IP network enables to secure the network from unauthorized access through use of a firewall.

3.3 Demonstrate Virtual LAN

The concept of a virtual LAN enables the LAN administrator to logically reconfigure a network without having to physically move the users or the PCs on the network. This is a desirable feature for many practical networks.

Initially, a LAN consisting of six computers belonging to the same workgroup say, LAN1, is setup using a Layer-2 switch. Next it is verified that all the computers that belong to the same workgroup, LAN1, are accessible from one another. Following this exercise, students are to make a note of port number to which each of the computers is connected. Then the Layer-2 switch is programmed with three ports (where three computers are connected) to belong to a Virtual LAN, named VLAN1, and the other three ports (where the other three computers are connected) to belong to a Virtual LAN, named VLAN2. Now the students are to make an attempt to access the computers on VLAN2 or VLAN1 from a computer on VLAN1 or VLAN2. If the Virtual LANs are correctly setup, then the computers across different Virtual LANs should not be accessible even though they belong to the same workgroup.

3.4 Demonstrate LAN-WAN Connectivity

The laboratory is equipped with DSUs, routers, and a FT1 line (loop back) to interconnect the two LANs to build a

WAN. Two separate LANs are built using a Layer-2 switch. Each of the switches is then connected to an Ethernet port on a router with a built in DSU. The two DSUs are connected using a cross-over T1 line, thus connecting one LAN to another LAN. This setup demonstrates a point-to-point WAN.

4. LABORATORY EXPERIMENTS

The next phase of the academic activity was to incorporate five laboratory-based experiments into the course design that would provide the students with an opportunity to reinforce the key concepts developed in the classroom. Each of the laboratory experiment was designed to take no more than thirty minutes to complete and was tested by the author and a select number of students in the semester preceding the first offering of the class. The laboratory-based activities also required students to develop a logical approach to troubleshooting and resolving network related problems.

4.1 Lab 1: Introduction to Ethernet LAN Construction

The intent of this laboratory exercise is to have students identify the ports at the back of the computers, switches, and routers. Additionally, students have an opportunity to feel and touch the cables and the connectors, and explore how the cables are laid to connect the computers to a patch panel mounted on a rack. This demonstrates the physical layer of the OSI model.

4.2 Lab 2: Network Diagramming

This laboratory setup is designed so that the students can begin to practice using VISIO, network-diagramming software, which they were introduced to in a previous Systems Analysis class. They are to diagram the network setup in the Information Systems Laboratory.

4.3 Lab 3: Setup a Network using WIN 2000

In this laboratory exercise, students have to configure network parameters to establish network connectivity at the network layer (Layer-3 of the OSI model). This experiment demonstrates the network layer protocols.

4.4 Lab 4: Enable/Disable a port on a Layer-2 switch to isolate a workstation from the network

This laboratory setup demonstrates Layer-2 protocols (Ethernet), which functions independent of Layer-3 protocols. The students also get an opportunity to configure the parameters of the asynchronous protocol to establish a logical link over a serial port of a PC connected to a serial port of the switch using a RS-232 cable.

4.5 Lab 5: Setup two Virtual LANs and isolate a group of workstations

In this laboratory experiment, students divide one physical LAN into two Virtual LANs using a Layer-2 switch.

4.6 Operational Issues

The author with the help of faculty assistance maintained the network laboratory. Access to this laboratory was permitted during the designated laboratory hours. The problem encountered in implementing the laboratory was the limited number of workstations compared the number of students per class. To remedy this situation, alternating laboratory sessions of half an-hour each were offered per class section.

5. LOCAL AREA NETWOK PROJECT

At the beginning of the semester, students were asked to form a group of four, and were given the task of selecting a company for which they would propose a LAN to support Information Systems. Each group had to carry out initial research and submit a business summary on the recommended LAN solution for the company. The use of a group project highlighted the dynamics of group learning, scheduling, resource allocation, and conflict resolution in the corporate environment. The goal of the project was for students to develop an understanding of networking hardware and software components, and thus provide a framework for the class lectures.

5.1 Network Proposal Guideline

The project is an opportunity to design a LAN using a minimum of 100 nodes. This is a group project, with no more than four students per group.

- The group may select any type of business.
- Needs Analysis must address the company's Information System infrastructure.
- The group may choose any architecture, topology, hardware, and software to design the network solution for the company.
- Design the floor plan and the cable plan for the data network. The cable plan should indicate all nodes.
- Identify the individual departments within the company and present a logical diagram of the company's organization.
- The logical layout of the data network must be presented.
- All costs including network devices, cabling, and labor must be detailed.
- A timeline must be included.

The deliverable from each group is a bound copy (25 to 30 pages) describing the recommended LAN solution for their choice of a company. The group projects are evaluated against the guidelines stated above. A passing grade is allocated to the project that just meets the guidelines. A project that details a business solution is awarded higher points. Each member of the group gets the same number of points on the group project.

6. CONCLUSIONS

This teaching tip presents a course design and discusses the logistics of offering a Telecommunications and Data Networking course for undergraduates. The course covers LAN design, and practical LAN administration skills. The classes taught by the author were popular with the students.

The laboratory too was successful as no student had difficulty in completing the laboratory assignments in the allotted time. At the end of the semester, a random sample of students from four class sections (each of the class sections had about 35 students) was polled regarding their perception of the course. Students indicated that they enjoyed the class lectures, and the case studies presented in the classroom added a practical value to data networking concepts. A majority of students indicated that they wanted to spend more time in the laboratory, and possibly explore a greater number of experiments because they perceived this as an opportunity to improve their job related skills. The students enjoyed the group project, because it gave them an opportunity to put together the networking hardware and software tools to design a LAN for a business. I am continuing to offer laboratory based experiments and a group project as a part of their final grade.

With the success of this undergraduate course, the department approved an upper-division elective course in Advanced Data Communications for the IS undergraduate students. This course is taught by this author, and covers fundamentals of Internet Protocols (TCP/IP), routing protocols, firewall design, and network security protocols. The lectures are supplemented with laboratory-based assignments to provide hands-on experience with configuring IP networks.

7. REFERENCES

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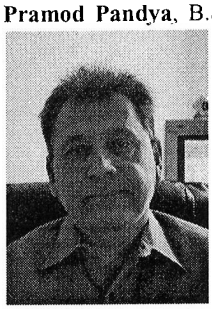
AUTHOR BIOGRAPHY



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Appendix 1 - Tentative Course Outline

Basic Concepts (Weeks 1 through 2)
Data Communication Model: The OSI Model
Components of a Data Communication System
Information Systems Architecture

Physical Layer (Week 3)
Line Configuration
Transmission Modes/Media, Topology
Data Encoding

Data Link Control Protocols (Week 4)
Media Access (Line Discipline)
Flow/Error Control
Asynchronous/Synchronous Transmission

Local Area Networks (Weeks 5 through 6)
Network Operating System
LAN Design and Specifications
Cable and Connectors
Ethernet (CSMA/CD)
Shared 10/100 – Switched Ethernet

Network Layer Protocols (Weeks 7 through 9)
TCP/IP
Backbone Network Design

Wide Area Network (Weeks 10 through 12)
Transmission Codes – Serial Interface (RS-232)
Bandwidth of Voice Circuit
Analog Transmission of Digital Data
Digital Transmission of Analog Data
Multiplexing – PSTN – T1 Circuits
Circuit Switched/Packet Switched Networks

The Internet (Week 13)

Network Security (Week 14)