AC 2008-1887: INTEGRATED CURRICULUM AND LABORATORY DEVELOPMENT OF AN UNDERGRADUATE TELECOMMUNICATIONS AND COMPUTER NETWORKING PROGRAM

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Integrated Curriculum and Laboratory Development of an Undergraduate Telecommunications and Computer Networking Program

Abstract

This paper describes the ongoing development of the integrated telecom curriculum and laboratories. The current laboratory includes a general networking lab and a network security lab. Eventually, we want to offer an enriched curriculum supported by an integrated network environment where traditional telephone network, VOIP, data network and backbone fiber optic network coexist with data, voice and video traffic. Our goal for the lab is to allow students to see an integrated telecommunication system, rather than many isolated parts. We will discuss the current curriculum and laboratory approach and present a prototype of an integrated advanced undergraduate telecommunications and computer networking laboratory.

Introduction

The current growth in telecommunications indicates that, in the near future, not only data, but audio and video services will be integrated and there will be a growing market for bundled services. This industry trend requires broader technical expertise at all levels to develop applications, support the new technologies and maintain the competitive edge required for success in the global environment. Having recognized these needs, Southeast Missouri State University developed a new Telecommunications and Computer Networking (TCN) option to educate and train the necessary workforce for supporting these initiatives.

The Department of Industrial & Engineering Technology at Southeast Missouri State University started the TCN option under the BSIT (BS Industrial Technology) degree in fall 2005 as a major, expanding on an earlier electronic curriculum. The TCN option is a new, unique and multidisciplinary program that offers a variety of courses to give students a broad yet solid background in the area of study. It is unique in that it not only tries to offer students foundation and principles of system design and development from the engineering perspective but also try to expose them extensively to new emerging technologies and equipments through its integrated curriculum and laboratories.

The current TCN curriculum covers digital circuit design, telecommunications and fiber optics, computer networking, network routing and switching, network design and maintenance, system analysis and design, wireless communications and networks, server techniques, and network security. Considering that standard engineering courses focus on the technical aspects, but under-address the challenges in system design and configuration, maintenance and troubleshooting, and pure technical schools do not equip students with enough theoretical background, we created a curriculum to balance both theoretical and technical requirements.

Ma & Nickerson [1] found that hands-on laboratories adhered to goals of the Accreditation Board for Engineering and Technology[2] and gave students a conceptual understanding of engineering, as well as, design, social and professional skills. Survey results from Etkina & Murthy [3] indicate

that laboratory activities help students learn the content, work in groups and apply the content to the real world. Accompanying the TCN curriculum are two networking laboratories, as will be introduced in the section of "Current Laboratory Approach". The two laboratories features advanced and state-of-the-art devices such as computers, laptops, routers, switches, security appliances, wireless access points, telecommunications training stations, and are extensively used by the students for class experiments and course projects. We have developed on average of 10 lab experiments for each TCN course and strongly believe that hands-on, real-life examples will be invaluable for students to absorb, consolidate/strengthen and apply theory knowledge.

As the program continues to grow in enrollment, courses and equipment, some additional thoughts arise. One thought is that often lab experiments focus on one area. For instance, currently, each course has various laboratory experiments, but the activities are confined to its specific subject. For example, in a networking class, students set up networks and observe the performance of the data services; in a telephony class, students set up voice communications and observe the PSTN (Public Switching Telephone Network) service. It is possible to build an integrated lab featuring LANs, WANs, voice, data, wire line, wireless and security technologies. An integrated lab will be more beneficial to students because they could observe the network performance when both data and voice services coexist and they can see how the technologies affect each other. Our goal is that the knowledge from different telecom areas can be integrated, so that the students not only understand every individual topic, but also see the big picture of the complete telecommunications system and how the components interact with each other. This knowledge coupled with true hands-on experience will provide valuable skills students need for success in their careers.

Another thought is with converging of Internet technologies. The future Internet will have a converged network architecture delivering voice, video and data over IP. Thus, adding additional courses like IP Telephony and Network Management is sensible. The addition of these new courses can enrich and enhance the current TCN curriculum.

In this paper, we describe the ongoing development of the integrated telecom curriculum and laboratories. The current TCN laboratory includes a general networking lab and a network security lab. Eventually, we want to offer an enriched curriculum supported by an integrated network environment where traditional telephone network, VOIP, data network and backbone fiber optic network coexist with data, voice and video traffic. Our goal for the lab is to allow students to see an integrated telecommunication system, rather than many isolated parts. The hands-on experiences obtained through such a complete system will also enhance the theory knowledge from our integrated curriculum, no matter what topic they are learning.

The paper is organized as follows. We first introduce the current TCN curriculum and laboratory approach. Then, we will present the integrated advanced TCN laboratory that is under development, as well as, how to assess the outcome of such an approach. Finally, we conclude the paper and address the future work.

The TCN Curriculum

The TCN option in the IET department was initiated with expanding its Electronics curriculum. Originally, there were two networking courses: ET275, "Network Routing and Switching I" and ET375, "Network Routing and Switching II". In 2001, the department recognized the need for an expanded telecommunications and computer networking curriculum to keep up with the increasing growth of the industry. The TCN option was officially started in fall 2005 with a series of new courses designed and developed, as shown in Figure 1. In the figure, the arrows show that students must finish the corresponding prerequisite courses in order to register for a higher level course. The courses shown here are the TCN major courses only and students have to finish other BSIT core courses.

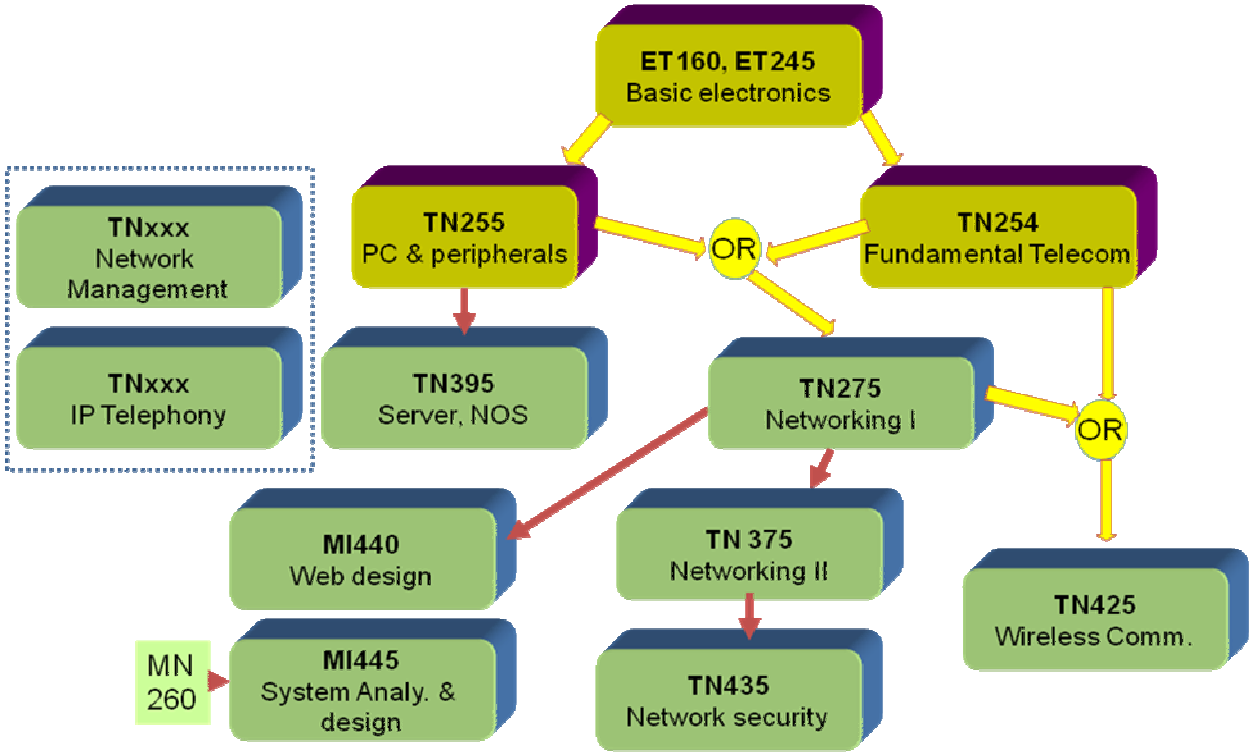

Figure 1. TCN Curriculum

Students with the TCN major first finish courses in electronics to gain backgrounds in basic electronic circuits and logical circuit design. Then, they are introduced to TN255, "Computer Peripherals", and TN245, "Fiber Optics and Network Communications". These two courses introduce computers, fundamentals of telecommunications and optical fiber communications. TN 275 and TN375 are two networking courses, introducing the Internet, layered communications, networking models, networking services and protocols, design, implement and troubleshooting computer networks. TN395 introduces network operating systems with focus on system and network administration, server setup, maintenance, and troubleshooting. TN425 overviews wireless communication technology and wireless networking on different generations of cellular networks and wireless local loop, Wireless LANs (IEEE 802.11), Bluetooth technology, Mobile IP, ad hoc and sensor networks. Lastly, TN435 presents network security topics such as security services, threats and mechanisms; principle of cryptography; system security such as viruses, intrusion detection and firewalls.

In Figure 1, two TN courses, "Network Management" and "IP Telephony" are framed in dashed lines. These two courses are currently unavailable and will be developed in the near future. In addition, the TN students take two other courses in Management Information System, MI440 "Web Design for Electronic Commerce" and MI445 "Systems Analysis & Design". These two courses give students real-world business situations,and help enhance the concepts of system design, implementation and maintenance.

Current Laboratory Approach

Currently, the TCN program has two laboratories, a wired networking lab and a wireless and network security lab.

1. Wired Networking Lab

The wired networking lab supports TN254, TN275, TN375, and TN395. The lab has 15 computer stations, each having two 2.4 GHz Pentium P4 computers and flat display monitors. The computers are used by TN275 and TN375 students to set up, configure and troubleshoot networks and related services. Other networking devices used by these two courses include Cisco routers, Cisco switches, and 3com switches. The abundance of networking devices ensure that even for a class of twenty students, no more than four students are assigned to a single group; therefore, every student has enough hands-on practice on the involved devices.

The networking lab also features a dedicated server with Microsoft Windows Server 2003. This server serves several purposes. First, it is a domain controller that controls all the computers in the lab. Second, it is the file server, DNS and DHCP server for the lab, and lastly, it enables the lab computers to be a private network and share the Internet access. It is also used by TN395 to demonstrate the server functionalities.

Every computer in the lab has a default drive installed Windows XP and it also supports removable hard drives. In TN395 laboratories, student can install and configure network operating systems such as Windows Server 2003 and Linux on removable drives without affecting the default networking lab setup.

The networking lab also has four digital communications training systems used by TN254. Each training system contains 20 modules to provide lab activities on basic and advanced principles of digital communications including coding, modulation, time-division multiplexing/demultiplexing, and T1/CEPT PCM transmission.

In addition to the above equipments, wire/wireless network simulation packages are available to simulate environments and situations that cannot be implemented in laboratories.

2. Wireless and Network Security Lab

The wireless and network security lab currently supports TN425 and TN435. This laboratory features laptops, security appliances and wireless access points/routers. The laptop computers

have built-in WiFi and Bluetooth technologies. The equipment enables TN425 students to design and implement wireless local area networks and ad hoc networks. Other wireless lab activities include signal strength measurement and network performance measurement. TN425 laboratory activities are still under development.

The network security lab allows TN435 students to build four local area networks and interconnect them into an internet. With a security appliance for each local area network, lab activities are developed to cover topics such as vulnerability detection, intrusion detection, security policies, firewall configuration, access control, authentication, encryption and VPNs.

A Prototype of an Integrated Advanced TCN Laboratory

As mentioned before, although currently each TCN course offers various laboratory experiments, the activities are mostly confined in its specific subjects. A better idea would be to build a complete telecommunications system integrating the knowledge from different TCN courses. We believe that the hands-on experiences obtained through such a complete system will enhance the theoretical knowledge and help students relate the concepts to the overall system.

Recently, the department received donations from Falcon Communications Inc. and Time Warner Telecom including a Nortel DMS-10 switching system, an IP/PBX, IP phones, and SONET OC-3 add/drop multiplexers. Together with the equipment in the current two networking laboratories, we plan on developing an integrated advanced TCN laboratory. It will present an integrated network environment where traditional telephone network, VOIP, data network and backbone fiber optic network coexist with data, voice and video traffic. Figure 2 shows the future advanced TCN laboratory configuration.

The DMS-10 system is a carrier class central office switching platform offering service options ranging from simple dial tone to advanced voice and data networking. Our DMS-10 can support up to 10,000 lines. Although this is more than enough (much more than) required by a laboratory environment, the significant benefits it offers the students on exemplifying the PSTN functionalities such as dial tone, local loop, central office and system configuration are invaluable. Actually, it is very fortunate for an education unit to have such a system.

In Figure 2, the backbone network will be a SONET ring composed of OC-3 add-drop multiplexers/demultiplexers, offering a speed of 155Mbps. The add-drop multiplexers support DS-1, DS-3, and Ethernet connections, which enable the connection of different types of networks. The PSTN is emulated with the DMS-10 and the connected traditional telephones. The IP telephony/VOIP service is provided by the IP/PBX and IP phones (and/or computers). Wireless Local Area Networks (WLANs) and secured/unsecured data network can also be integrated. The Wired Data Network in Figure 2 represents the current general networking lab.

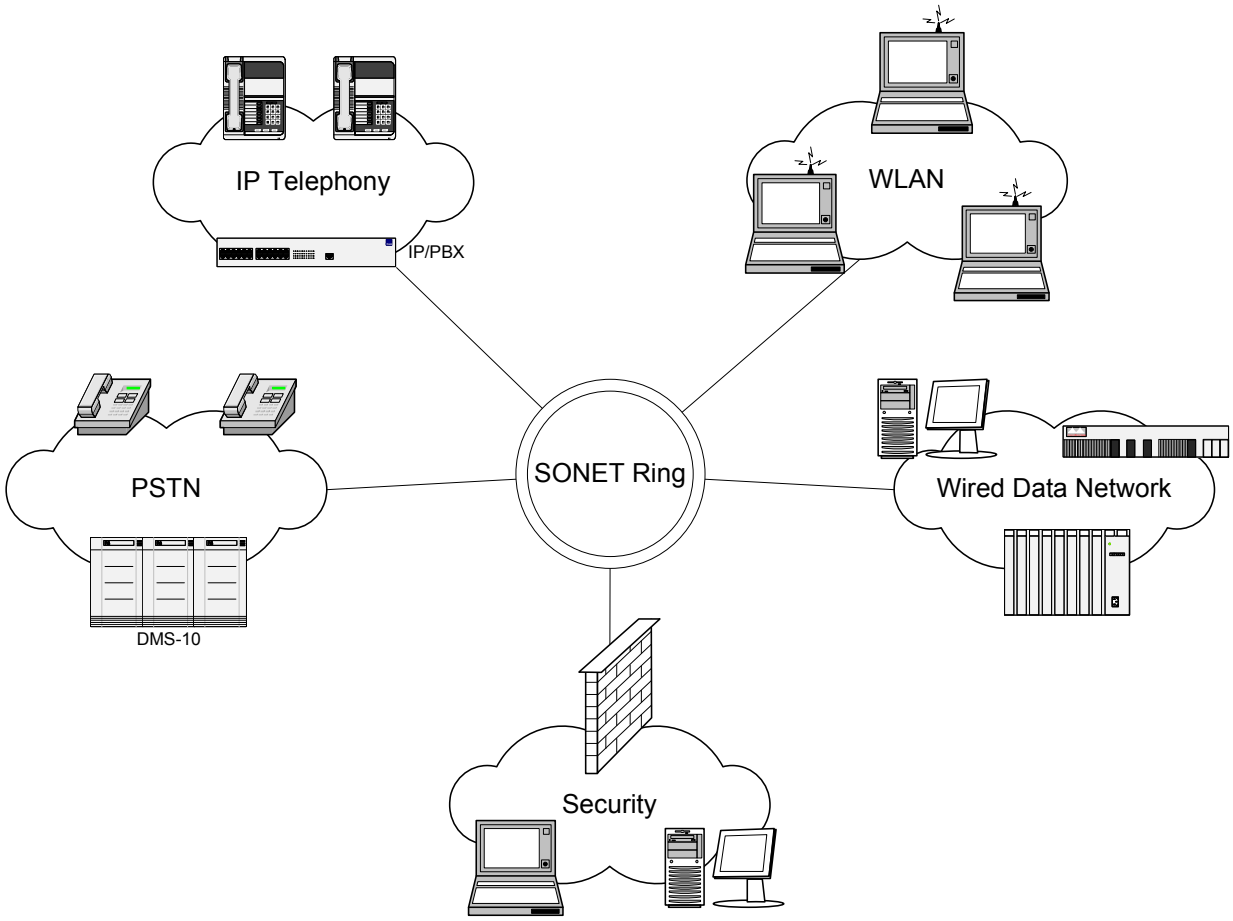

Figure2. An Integrated Advanced TCN Laboratory

Our goal is that, eventually, the current two networking labs are integrated together to provide a complete telecommunications system. Students from different courses not only can practice and apply the knowledge learned from a specific area, but also can relate the concepts to the overall system.

Evaluation

To determine the effectiveness of the new curriculum and laboratory development, three levels of evaluation will be conducted. The first level is the standard university required course evaluation at the end of each semester, which provides general feedback of the courses, students' expectation, and a rough comparison with other programs/options in the department. At the second level, we will collect tests, comments and suggestions from student volunteers using the new labs (posttests) and compare them with the ones from previous/current labs without an integrated lab environment (pretests). The last level of evaluation will be conducted by an external industry advisory committee. The committee members periodically review course materials and lab developments and suggest changes. Based on these three levels of evaluation, eventually, we will continue to update and refine the development of courses and labs.

Conclusions and Future Work

In this paper, we describe the ongoing development of the integrated telecom curriculum and laboratories. Currently, we already have most of the described equipments. Next, we plan on setting up and testing the DMS-10, IP/PBX and the SONET devices. Following the testing, we will interconnect the different networks. Additionally, we will develop new courses and lab activities to fully utilize the integrated laboratory resources. We also plan to evaluate how this new integrated laboratory affects teaching and the learning experience. Finally, we will continue to expand the integrated curriculum and laboratory, such as setting up a student-operated Network Operations Center (NOC) for the campus or even the local region and adding wireless cellular communications to the laboratory.

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