2006-2160: DEVELOPING A CAPSTONE COURSE FOR TELECOMMUNICATIONS ENGINEERING TECHNOLOGY

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DEVELOPING A CAPSTONE COURSE FOR TELECOMMUNICATIONS ENGINEERING TECHNOLOGY

Abstract

The Telecommunications Engineering Technology (TCET) program at Southern Polytechnic State University (SPSU) has experienced tremendous growth since its inception in 1999. The program has been one of the fastest growing programs within the Electrical and Computer Engineering Technology (ECET) Department, and received its first ever full ABET accreditation in 2003, retroactive to 2000.

The TCET students get hands-on experiences in telecommunications networks analysis and the various aspects related to the administration and management of such networks. A primary goal of the program from its inception has been to develop a capstone course in which students demonstrate their competence gained via the program by the successful completion of a team project and associated report.

This paper discusses the development of the telecommunications project course as a capstone course for the TCET program at SPSU. The most recent project involved the setting up of a voice-over-IP (VoIP) network using Cisco routers and equipment available in our telecommunications laboratory. The VoIP network operated over a Frame Relay (FR) cloud and incorporated security aspects into the design. In the final design, the students demonstrated that the network could also be used for sending video over the network. Preliminary results based on student performance and feed-back from those students who have taken the course are presented; they indicate that the course has been successful in meeting the intended goals. Due to the successful outcome the ECET department has accepted this course to serve as the capstone course for the TCET program.

I. Introduction

Eight years ago a multidisciplinary Baccalaureate degree program in Telecommunications Engineering Technology (BSTCET) was approved by the University System of Georgia Board of Regents and offered at Southern Polytechnic State University[1]. The BSTCET program is a multidisciplinary degree program that has evolved via a process of continuous improvement. One such improvement has been the transformation of the senior project course into a comprehensive telecommunications capstone course. The current program is comprised of four major components: Electrical and Computer Engineering Technology (ECET) prerequisites, university core courses, management courses, and the following eight BSTCET-specific courses[2,3,4].

- ECET 2800 – Introduction to Telecommunications
- ECET 3810 – C++, Java, and HTML
- ECET 4820 – Communication Networks and the Internet

- ECET 4830 – Telecommunications Management
- ECET 4840 – Advanced Telecommunications
- ECET 4850 – TCET Capstone
- 2 TCET Electives

With the exception of ECET 2800 all BSTCET courses possess a full compliment of hands-on laboratory exercises involving the use of hardware and software-based telecommunications technologies including: routers, switches, concentrators, workstations, servers, firewalls, operating systems, analyzers, simulators, and so on. ECET 2800, though not lab based, introduces the student to the "big picture" of telecommunications including: protocols, standards, regulations, encoding, noise, modulation, POTS, and LAN/MAN/WAN concepts and technologies. Both theoretical and practical aspects of the program combine to equip the student with a complete set of skills and knowledge required to compete in the modern telecommunications industry.

Our current capstone course, ECET 4850, was originally titled "Telecommunications Project," wherein projects, such as the configuration of a specific router-based network, were initially assigned and then progressively evaluated at built-in milestones. Although a few telecommunications technologies -- e.g. VoIP via the routed network-- might be included in the project course, a holistic format was lacking; a comprehensive, practical course reflecting real-life telecommunications solutions design and implementation was needed.

II. Motivation for Creation of a Capstone Course

The Technology Accreditation Commission of ABET Inc. in its accreditation criteria[5] states that "Capstone or other integrating experiences must draw together diverse elements of the curriculum and develop student competence in focusing both technical and non-technical skills in solving problems." With this in mind, the TCET faculty set about developing its Telecommunications Project course into a full fledged capstone course that would serve as an integrating experience for our graduating seniors.

Using feedback and/or information from several sources including the ECET Industrial Advisory Board (IAB)[6,7], U.S. Department of Labor Bureau of Statictics[8], graduates of the program, and industrial experience of the faculty, it was determined that in addition to being able to simulate real-life telecommunication solutions design and implementation, individuals with team-oriented, up to date telecommunications experience are a valuable asset to would-be employers. Although some of the BSTCET courses provide such an experience, only the capstone course presents a single, multilayered telecommunications scenario.

In developing the course, several factors were considered essential for making it a meaningful capstone experience that would provide the students with some of the requisite skills desired by industry. Some of these factors included: technical content representative of rigid technical content that would represent state-of-the-art technology, team work, technical communications, management, and interpersonal skills.

III. Sample Projects

A. VoIP over Ethernet WAN

The first iteration of the capstone course involved the design and implementation of a communication network that utilized the voice over Internet Protocol (VoIP) over an Ethernet based Wide Area Network (WAN). The scope of activities performed by the students included the following:

- Researching VoIP products offered by competing providers, e.g. Cisco and Quintum Technologies
- Designing a network that could utilize VoIP
- Developing a working BOM for the project
- Implementing and configuring the network for the VoIP implementation
- Utilizing a network analyzer to capture voice packets and analyze the protocols used in the packets
- Analyzing the effects of data traffic congestion on VoIP Quality of Service (QoS) and protocol efficiency

The students were also expected to demonstrate their expertise in project management by developing a project management plan with GANTT charts for the capstone project. Although students were allowed to develop their own sub teams to accomplish various tasks, they received instruction about the overall team structure from the instructor with the following guidelines: i) students were to elect a project director, ii) sub teams were organized and assigned specific task(s) by the director, iii) sub teams reported periodically to the director about the progress of various sub goals set by the team towards the completion of assigned tasks, iv) the director facilitated inter-team communications, v) teams facilitated internal communications to determine exact processes required to meet their goals, and vi) the instructor interfaced with the project director for overall feedback and with individual teams in the capacity of "consultant." Students were required to produce a comprehensive report for their project and give an oral presentation to faculty, fellow students, and IAB members.

A typical example of a network design solution developed by students is shown in Figure 1. Figure 2 shows the configuration used for the VoIP demonstration. A typical Gantt chart for the project is shown in Figure 3, and Figure 4 shows a typical bill of materials (BOM).

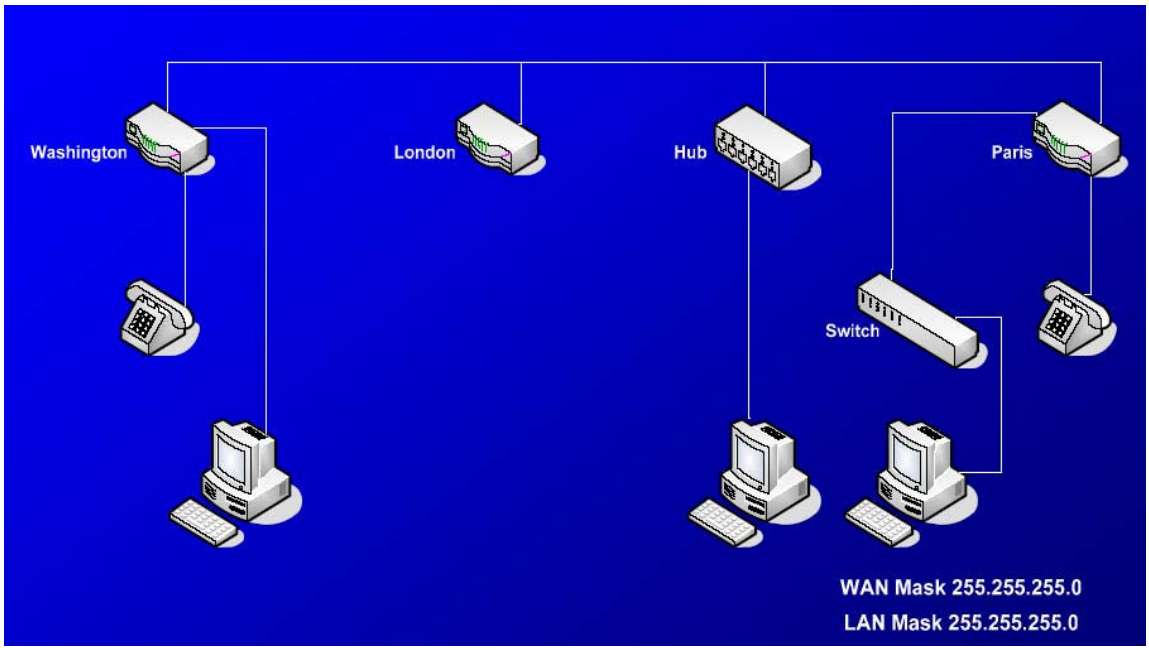

Figure 1. Typical VoIP network solution

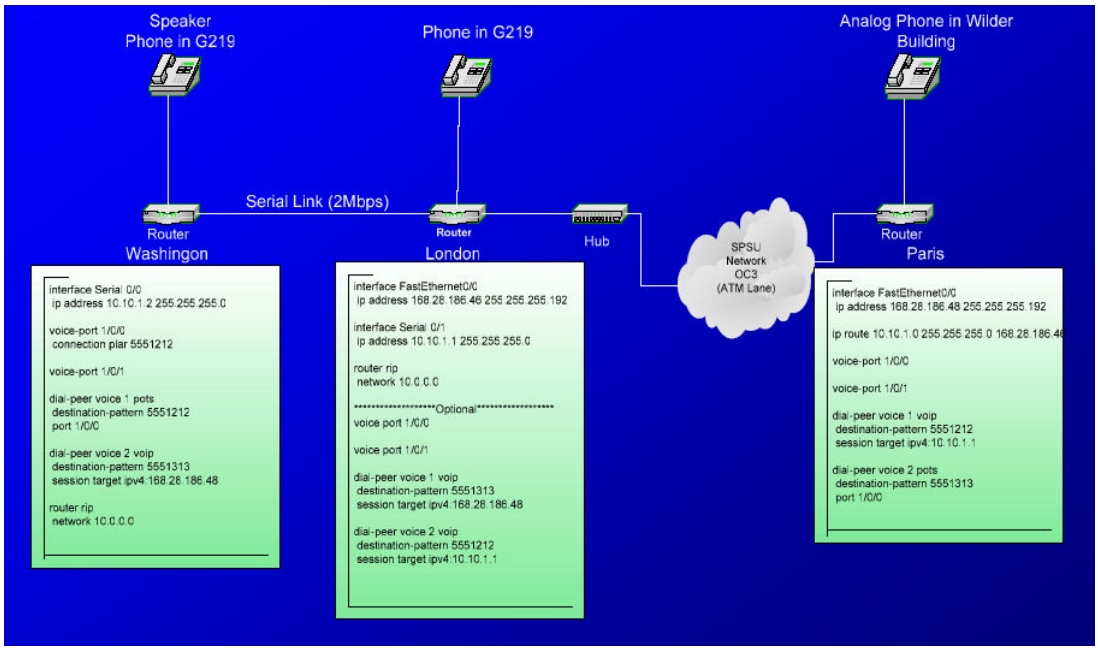

Figure 2. Voice over IP (VoIP) demonstration configuration

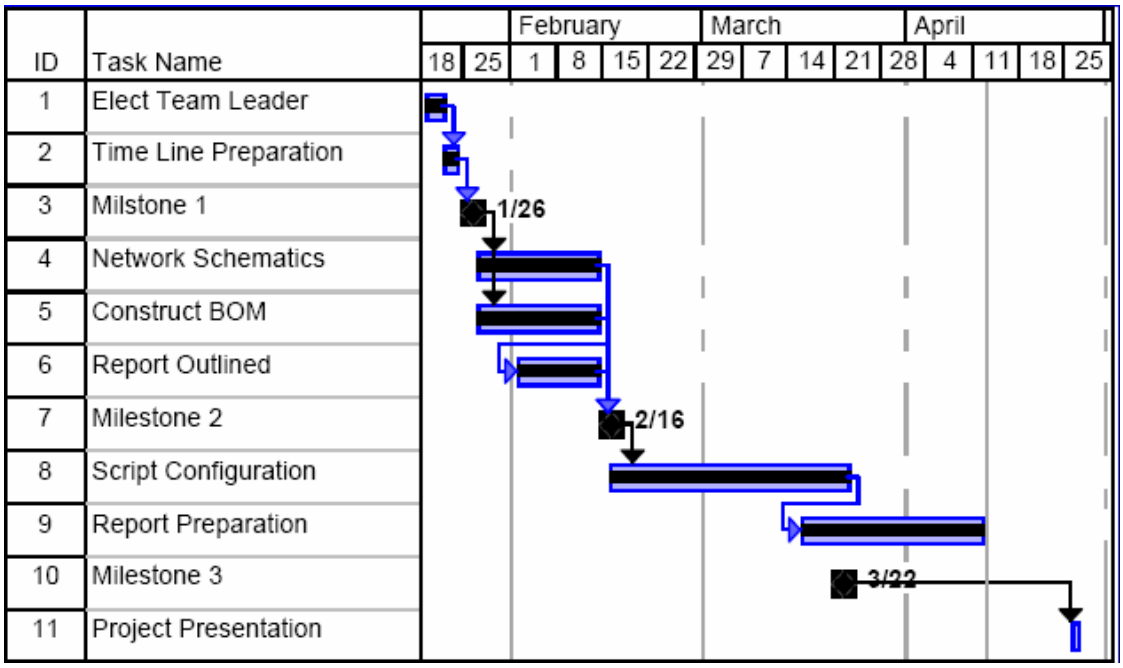

Figure 3. GANTT chart for VoIP project

B. VoIP over Frame Relay

The latest iteration of the capstone project calls for the design and development of a communication network that utilizes the voice over IP (VoIP) over a Frame Relay network. The scenario calls for developing a solution for a small company with offices in three locations within a major city. The offices are to be linked by a Frame Relay network, and the company would like to utilize the benefits of VoIP for their inter-office and external telephone communication needs. The solution provided should allow for telecommuting workers, sales personnel, and customers, to be able to access the network with varying degrees of security access. The scope of activities includes the following:

- Researching Frame Relay and VoIP products offered by vendors
- Designing the Frame Relay network solution
- Incorporating the VoIP design requirement
- Designing and implementing security requirements
- Developing a working BOM for the project
- Utilizing a network analyzer to capture voice packets and analyze the protocols used in the packets
- Studying the effects of traffic shaping on the voice quality of the network
- Analyzing the scope of the network security

Manuf Part #	Product Description	Quantity	Unit Price $	Total Price $
Quintum:	Tenor A800 Analog Series VoIP MultiPath Switch	1	1,198.00	1,198.00
Quintum:	Tenor D800 Digital Series VoIP MultiPath Switch T1,E1,PRI interfaces Up to 30 simultaneous VoIP calls	1	2,063.00	2,063.00
Quintum:	Tenor D3000 Digital Series Gatekeeper	1	2,964.00	2,964.00
Quintum	Tenor CMS 960 VoIP Carrier Multipath Switch	2	15,552.00	31,104.00
Quintum	DSP-120 DSP Resource Module supports up to 120 simultaneous VoIP calls	16	3,949.00	63,184.00
Quintum	DS-1 8 Port (T1/E1/PRI) Line Interface Card with built-in CSU.	6	3,949.00	23,694.00
Cisco	Cisco Catalyst 2924 Switch – 24 Port Auto Sensing Switch	2	3,600.00	7,200.00
Cisco	Cisco 2621 Modular Multiservice Access Router	3	2,259.00	6,777.00
Advanced Radius Billing Solutions	(AAA) Advanced Radius Server & License	2	2,860.00	5,720.00
			Total:	143,904.00

Figure 4. BOM for VoIP project

A typical Frame Relay VoIP network solution is shown in Figure 5. In this example, one router is utilized as a Frame Relay switch with the other routers connected to it.

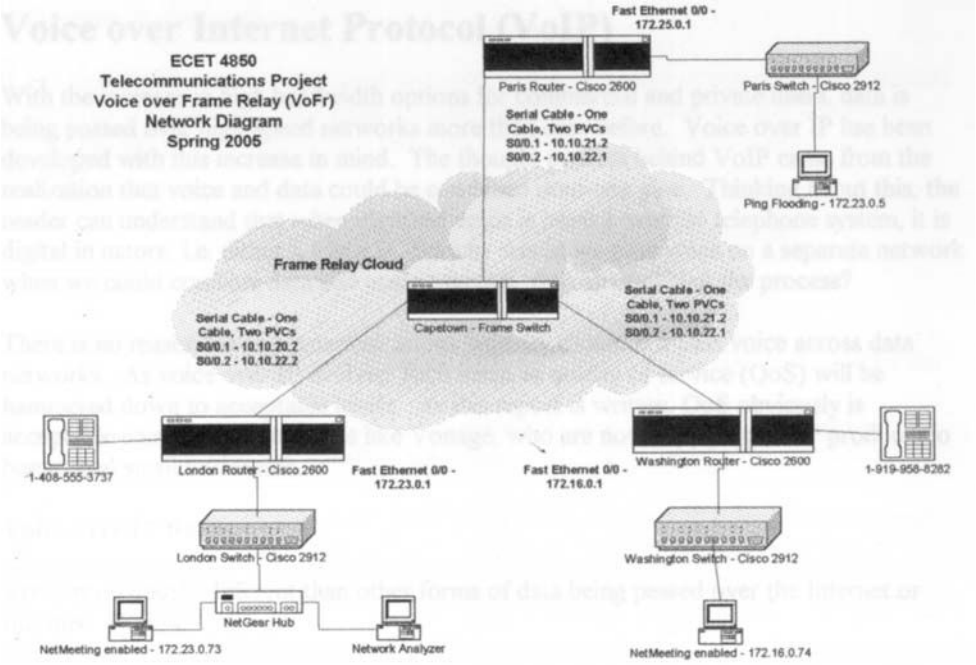

Figure 5. Typical VoIP over Fame Relay network solution

In this particular implementation, the telephones are shown directly connected to the routers. The terminals directly connected to the switches are either Microsoft NetMeeting enabled, used for ping flooding during traffic studies, or running the network analyzer software. With this network setup, the students were able to demonstrate the possibility of sending video as well as voice over the network. Access lists were utilized to control access to the network for security purposes.

It is anticipated that the scope of the capstone course will continue to be expanded and that future capstone projects will continue to emphasis network security. With the current industry emphasis on network security, it is envisioned that security will continue to play an important role in future network design, especially as new technology and applications are developed for the Internet.

IV. Evaluation and Preliminary Feedback

The evaluation process utilized for the capstone project is the following: i) sub teams evaluate each other's effort, ii) the project director/team leader evaluates each team's effectiveness and provides feedback to the instructor, iii) The instructor meets periodically with everyone and reviews team and individual effort, and iv) the whole class receives a portion of their grade

based on the milestone(s) performance and the final product/presentation. This interactive evaluation process allows the instructor to keep abreast of the project's progress through the role of "consultant", allows for identification of potential problems, and provides valuable feedback that is utilized in making revisions to the capstone project with the ultimate goal of improving the experience for the students.

Preliminary feedback from IAB members has been very positive. The students are encouraged to contact the IAB members for guidance with their projects and the IAB are invited to come and sit in on the student's presentations. The information derived from the IAB members' comments are being used to continuously improve the scope and quality of the capstone project.

Student feedback has also been extremely positive. There has been a general appreciation of the course in terms of consolidating the knowledge and skills that the students have accumulated throughout their curriculum. It provides them an opportunity to showcase their skills before their faculty, peers, and most especially in front of an industry audience.

V. Conclusion

The successful transformation of ECET 4850 from a telecommunications project course into a comprehensive capstone course has provided the TCET curriculum and, more importantly, TCET students with a valuable scenario-based, team-oriented environment used to integrate key skills and knowledge learned throughout the program. By assigning a complex, multilayered, time-dependent scenario students are confronted with typical, real-world expectations and must, therefore, rely on their technical, non-technical, and team-related skills in order to successfully organize their efforts and work towards the completion of their capstone assignment.

As demonstrated by a few iterations of ECET 4850 such a course should be continuously improved and refined to introduce recurring feedback and ever changing technical scenarios. Assessment tools, which include student evaluations, continued IAB feedback, and feedback from program graduates, are being developed to formalize the feedback process and aid in the continuous improvement goals of the course and TCET program. Wherever possible, real-world input should be incorporated into the course design; academic and corporate/governmental network scenario criteria should coincide. For instance, from IAB feedback and instructor observation, it was determined that an additional layer involving network security – VPN technology and network analysis tools were used – was required, and, therefore, was added to the most recent iteration of the course. Although implementation of the Cisco-based VPN was not fully successful, valuable feedback was acquired, which will be used to improve this layer in subsequent iterations.

Course content should be sufficiently rigorous, while integrating many curriculum concepts and technologies, so as to motivate the students to press hard to meet required goals and rely on their acquired abilities. Additionally, the capstone course should also be enjoyable and provide a meaningful experience that the student can draw upon as an employee within the telecommunications industry. In brief: the capstone course content and format should reflect the

desired knowledge and skills required of graduates of the TCET curriculum in final preparation for entering the telecommunications workforce.

References

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[4] URL: http://ecet.spsu.edu/home/Programs/Programs.php

[5] URL: http://www.abet.org

[6] URL: http://ecet.spsu.edu/home/Advisory-Board/Advisory-Board.php

[7] Asgill, A. and Ofosu, W., "Industrial Perspective on Modifications to Telecommunications Programs", Proceedings of the ASEE Annual Conference, Salt Lake City, Utah, June 2004, Session 3448.

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