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Work-in-Progress: Design and Development of a New Networking Information Technology Program and Laboratory

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Abstract

This paper describes the ongoing development of a new Bachelor of Science in Networking Information Technology (NIT) program. The balanced curriculum and laboratory of the program not only provides students with foundation and principles of networking and information technology (IT) systems but also exposes students extensively to new emerging technologies and equipment. In addition, the paper introduces the continuous upgrade of the laboratory that uses innovative ideas to provide student-centered, cost effective real hands-on education with flexibility and high adaptability to various education and learning approaches such as face-to-face, hybrid and online.

Introduction

The rapid growth of computer networking and information technology requires broader technical expertise at all levels to support applications, apply the new technologies and maintain the competitive edge required for success in the global environment. Having recognized these needs, the Computer Electronics and Graphics Technology Department at Central Connecticut State University developed a new degree program in Networking Information Technology (NIT) which will continue to educate and train the necessary workforce for supporting these initiatives.

The predecessor of NIT is the Networking Technology option under the BS Industrial Technology degree, started in Fall 2001. With its multidisciplinary curriculum, such as electronics, computer science, business, and technology management, the enrollment of the option successfully grows to about 100 students. This provides a solid foundation for an independent degree program in this area. In addition, the feedback from industry demonstrates that a broad curriculum with more up-to-date networking technologies as well as related information technology areas is more favorable. Therefore, the faculty developed the new Bachelor of Science in Networking Information Technology program with an updated curriculum.

The faculty believe that a curriculum balancing both the theoretical and technical requirements is the best for student's career future and industry's needs in a long run. The new degree program is unique in this aspect because it not only tries to expose students to new emerging technologies and equipments through its updated curriculum and laboratories but also offers students foundation and principles of system design and development. The department has been working with the industry to make sure that the curriculum reflects the rapid growing IT industry and covers a wide spectrum. The new program's laboratory is under continuous update to enhance

student's hands-on experience with cutting-edge equipment. Similar to the curriculum design, the laboratory development benefits significantly from industry help and donation.

This paper presents the curriculum and laboratory upgrade. The paper is organized as follows. Firstly, the role of industry is introduced. Then based on the feedback from industry, the updated NIT curriculum is presented, followed by the upgraded NIT laboratory. Finally, the paper concludes with the future work.

Collaboration With Industry

The department has a very good relationship with local industry. The program's Industry Advisory Board (IAB) consists of members with broad backgrounds in networking and IT. The annual IAB meeting collects constructive suggestions and feedback on program strength and weaknesses, curriculum revision, laboratory set up, job and outreach opportunities, soft skills students should equip with, etc.

Local industry is also a rich source of the program's highly qualified part-time faculty. Their expertise is essential to enriching the curriculum and set up a direct connection between students and industry's needs. The courses taught by them, for example, server and system administration and enterprise messaging systems, usually require the content reflecting industry change more timely than the fundamental courses.

The department's connection with industry also set up a channel for students to explore internship opportunities, which is required for their graduation. The IAB members are invited to visit our classroom frequently and interact with students directly. Their presentations give students an insight to what industry is looking for. It's worth mentioning that this connection is also set up at school level [1] and university level [2] collaborated with the department, providing students multiple but consistent channels to industry. In addition, donation from the local industry helps upgrade the NIT laboratory with cutting-edge equipment.

In summary, the industry has provided the new program with various supports including ideas, expertise, equipment, workshop and internship. NIT Students will be exposed to industry right after they enter the program till they graduate.

The Networking Information Technology Curriculum

Figure 1 shows the NIT major courses. To address the feedback from the industry and meet future needs, the new program's curriculum has been significantly updated. In addition to updating some existing courses, several new courses are added. Firstly, CET 179 Basic Network Administration is added to the new curriculum. The faculty believe a 100-level major course can provide students a more solid foundation with various concepts and skills required by upper level courses. Also it allows students to get familiar with their major as well as the program and faculty from their early time on campus, which is essential to their success in the program.

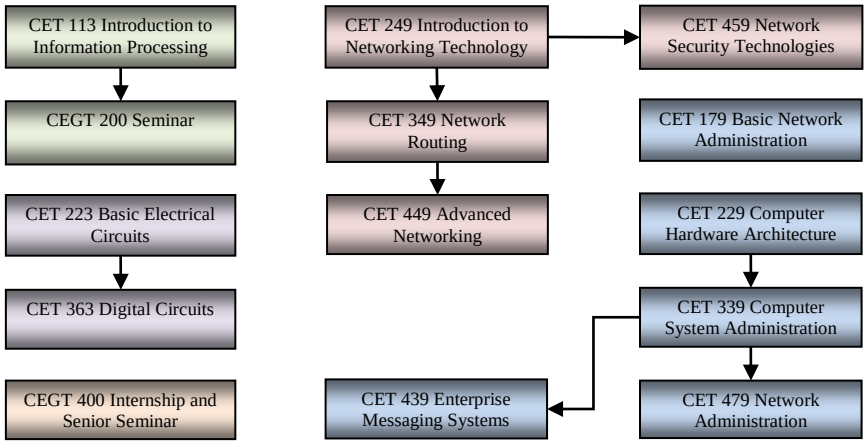

Figure 1. NIT Major Courses

Another area addressed is the topic of network security and a new required major course CET 459 is added. This course is designed to give students a broad introduction to network and information security such as security services, threats and mechanisms; principle of cryptography; system security such as viruses, intrusion detection and firewalls.

Due to the important role of timely communication in today's globalized economy, CET 439 Enterprise Messaging Systems is developed and added to the program. This course complements the existing Windows Server and Linux server administration courses and allows students to build up more comprehensive and important system management and administration skills.

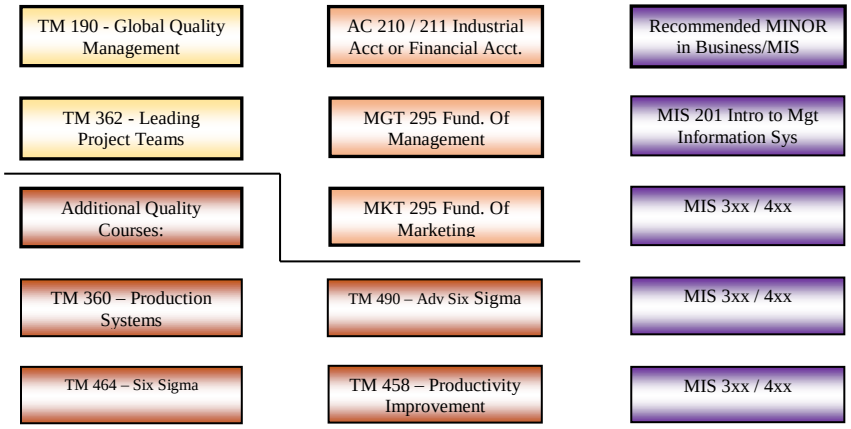

Figure 2. Business & Related Major / Minor Courses

Students need to finish other core courses including management, marketing, accounting, project management, and quality management, as shown in Figure 2. To further expand student's academic background, various directed or free electives are available in related areas such as software development, fiber optics, electrical communications, management information

systems, etc. According to the Association of Technology, Management and Applied Engineering [3], programs seeking accreditation must have the following: 18-36 semester hours in general education, 6-18 semester hours in mathematics, 6-18 semester hours in physical sciences, 12-24 hours in management, 24-36 semester hours in technical, 0-18 in general electives. Figure 1b illustrates the "management" component of the NIT degree program including the technology management courses, management, marketing, and accounting. Students are encouraged to complete a business minor with an emphasis in management information systems if possible to better round out their degree program.

In total, there are 22 credits available for directed and/or free electives and students are encouraged to take a minor in an area of their interest. Study [4] shows that IT graduate candidates with technical skills lack necessary business know-how and 43% of employers reported a lack of suitable candidates for IT and TELECOM roles due to a lack of business knowledge surrounding relationship management, business process analysis and design, project and program management. The study also states that "technical skills alone are not enough. Increasingly, IT professionals must have core business knowledge to cope with managing lifecycles, relationship management and project management." To bridge the gap, the faculty encourage students to take a Business minor with a focus on Management Information System. This also fits the NIT curriculum very well since some management and marketing courses required by the Business minor are already part of the NIT core courses. Another option for students to fulfill the elective credits is Technology Management (TM) courses. The program includes two TM courses (TM 190 and TM 362) as core requirement due to the fact that management, especially project management is one of the key skills the IT industry is looking for, as indicated by the study in [4]. The survey in [5] also reported that IT leaders are seeking project management skills as one of the top two IT skills. If students want to pursue a more diverse set of management skills, additional TM courses are available, as shown in Figure 1b.

The NIT Laboratory

Ma & Nickerson [6] found that hands-on laboratories adhered to goals of the Accreditation Board for Engineering and Technology [7] and gave students a conceptual understanding of engineering, as well as, design, social and professional skills. Survey results from Etkina & Murthy [8] indicate that laboratory activities help students learn the content, work in groups and apply the content to the real world. Accompanying the NIT curriculum are the advanced and state-of-the-art equipment such as computers, routers, switches, security appliances, wireless access points, virtual machines, etc., extensively used by the students for class experiments and course projects. For each of the NIT major courses, the faculty have developed more than ten lab experiments and strongly believe that hands-on, real-life examples will be invaluable for students to absorb, consolidate/strengthen and apply theoretical knowledge.

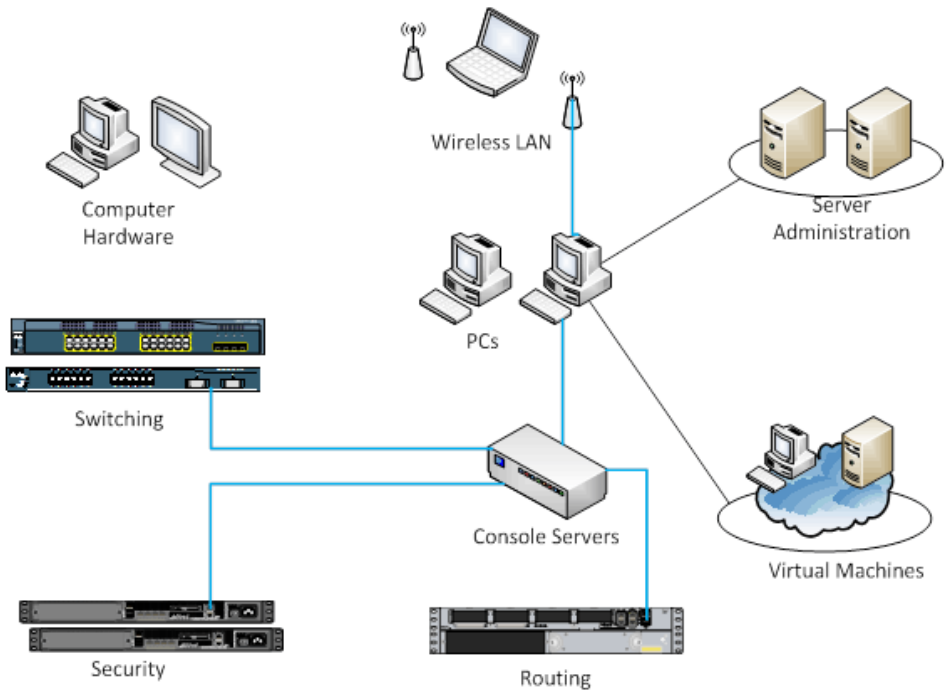

Figure 3. NIT Networking Laboratory

Currently, the department has two laboratories to support NIT curriculum, an electronics lab and a networking lab. The electronics lab supports the two electronics courses, CET 223 and CET 363, as well as other courses offered by the other programs in the department.

The networking lab, shown in Figure 3, supports all other major courses in the program. With limited space, supporting so many courses requires an integrated design. Aside from the 24 PCs solely used for CET 229 Computer Hardware Architecture, all other devices are integrated and used by multiple NIT courses. The center of the networking lab is 25 computer stations used by students to set up, configure, and troubleshoot networking equipment and server systems. To make sure students from different courses have their own software set and do not interfere with each other, the computer stations support removable hard drives. Every student in every course is assigned an exclusive hard drive for the whole semester.

In addition, virtual machines are also implemented for different courses. For example, some labs in CET 459 require four different operating systems. Without virtual machines, students have to work in groups with very limited hands-on experience.

Every computer station has three separate network connections for device configuration, lab computer management, and lab experiment connection. With the school's support and industry donation, the networking lab has 9 Cisco 2911 routers, 16 Cisco 2811 routers, over 30 Cisco switches (2950 series, 2970 series, 3500 series, etc.), and 3 Cisco ASA 3510 security appliances. The rich networking equipment provides each student plenty of hands-on practice in individual or small group labs.

To expose students to wireless LAN configuration, six wireless access points and six wireless network adapters have been added and will be integrated into some of the courses. In addition to the above equipment, network simulation packages are available to simulate environments and situations that cannot be implemented in laboratories.

Continuous Laboratory Upgrade

The current laboratory layout provides students with great hands-on experience from cabling, configuration, management to upgrading. In addition, many courses can share the same set of equipments. However, this design has a few disadvantages, mainly due to its isolation from the Internet. For example, it is difficult for students to make up a missed lab work caused by legitimate reasons such as illness or family emergency. Making up a lab at a different time is a challenge to the instructor. First, both the student and the instructor (or a qualified student worker) must agree on a time that they are both available. Second, the NIT lab must be available at the rescheduled time and not being used by another course. Third, a time slot must be available that both the NIT lab and the instructor are available so that the lab can be set up and prepared for the student. This time slot usually is right before the rescheduled make up time so that no other course interrupts the whole procedure. Finally, to make sure it doesn't interrupt other courses, the instructor must contact other instructors to see if they need that time to prepare or set up their labs. Clearly, it is an extra work just for one make-up. If multiple students missed a lab, even the same lab, it may not be possible to find a time for everybody and the above process has to be repeated for every student. Therefore, providing make-up lab could be a heavy load on the instructor and many times it just does not work.

For the same reason, it is also difficult for students to do extra lab work at their own time. There are times that students may want to repeat and review a lab after it is done in the class. Some other times, a student may want to do extra experiments or to prepare for certification exams. These needs cannot be well served with the current laboratory.

Another issue is that the program is limited by the current implementation and cannot offer online or remote education with hands-on experience on real equipments. Online courses usually require online labs or remote access to lab resources. If students have to come on campus to do the labs, they should be provided with time flexibility. Currently, the NIT laboratory is isolated from the Internet and no remote access is provided. The analysis above shows that the time flexibility is also very low. Simulation can be used for online education. However, the lack of experience on real equipment cannot fully prepare students for their future career or education.

The program currently is upgrading the NIT laboratory with a remote access feature. The ultimate goal is to make the lab available to the students via the Internet while keep all the current features. Remote access provides students with real equipment configuration experience. However, some hands-on experience may be missing, such as cabling, system or software installation, fault recovery, etc. That is why the current feature is also valuable and should be kept. The program has successfully secured a state funding to purchase new networking devices. Together with the existing devices, the laboratory will have enough equipment to support both features. Figure 4 shows the remote accessible section of the laboratory.

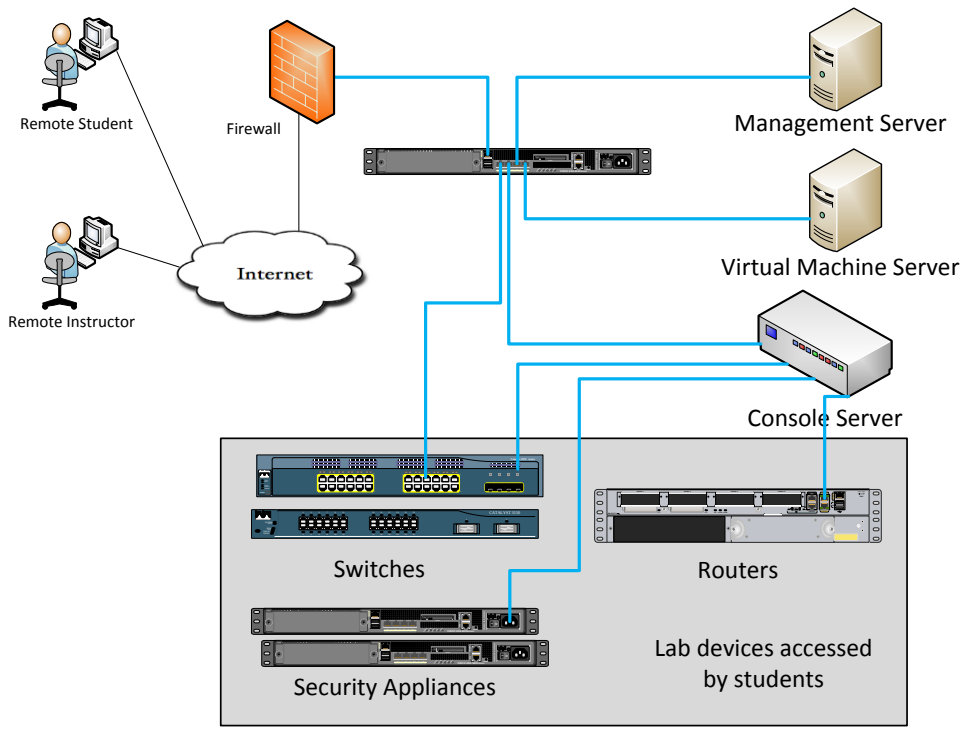

Figure 4. Remote Accessible Networking Laboratory

For remote lab access, there are similar commercial tools available, such as Netlab+ from NDG [9]. However, the proposed implementation will not only lower the costs, including the device cost and maintenance cost, but also be able to provide customized features. Some of such features include automated grading and lab content randomization. A database will be implemented on the management server and instructor can configure the database with the expected configurations required by each individual lab. After completing the lab, students can submit the configuration files to the server and the assessment is done automatically based on the instructor's configuration. The itemized assessment results or feedback can be provided to both instructor and students. This feature can be further extended to help instructors analyze the student performance. For example, the overall performance of a class on each specific item indicates the area that needs enhancement. Individual student's performance on the same item from different labs shows the progress the student has made so that the labs can be better tailored to more learning more efficient. Comparison with the previous classes on the same item provides instructors statistical feedback when they try different materials and pedagogies.

Lab content randomization can prevent students from copying other students' configuration. This is particularly important when hands-on exams are offered to the remote students. The content that can be randomized includes the addresses and numeric values. This can be achieved by using variables when instructor configures the labs on the management server. In addition, items to be configured and the network topology can also be randomized. For example, if there are multiple computers in the network and the traffic from one of them should be blocked, the instructor can configure the lab to require students block a random one. A random network topology can be generated if there are more than required devices or connections available in the

physical topology. For example, if multiple cables are used to connect two switches, the lab can use any one of them and students have to configure different switch ports each time.

Other features can also be implemented on the management server, such as online lab scheduling and automated lab setup so that the laboratory can provide both instructors and students with time flexibility.

Conclusions

In this paper, the authors describe the development of a new networking information technology program, and its curriculum and laboratory upgrade. The program has been approved by the university and Board of Regents and is officially launched in Spring 2014. The faculty have been working on the new program assessment, evaluation, and the program has been accredited by ATMAE. Currently, the laboratory is being upgraded with innovative ideas to help students enhance their learning experience and pursue success of their future career.

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