Filling the Void in Computer Education: Establishing and Developing a Responsive Computer Network Engineering and Security Program

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Abstract

This paper presents the restructuring and reorganization of the Computer Network System Administration (CNSA) program at Michigan Technological University to offer a revolutionary program designed to optimize learning and successfully prepare students for industry. Established in 2003, the CNSA program has effectively redeveloped its curriculum to fill a critical void in computer/network education that computer science, computer engineering, computer information systems, and management information systems programs have not provided, by offering advanced courses in the critical areas of network/systems engineering, security engineering, network/systems administration and technical operations management. The program has developed an intensive lab component for 20 of its 21 courses (computer/cyber-ethics being exempt from a lab) that requires students to dynamically solve challenging problems that affect industry. Course recitations include projects associated with industry and often require students to present technical solutions with sound financial explanations to industry personnel affiliated with the project and also to students' peers. Senior-design projects have also been formatted for students to conduct significant research, submit a professional paper containing their findings and recommendations, and provide oral defense of project.

The objective of the revised program is to prepare students to respond successfully to evolving technical advancements, have experience in solving industry-related problems, demonstrate financial expertise regarding technical projects, and develop skills in the ability to articulate and present their ideas to both technical or non technical individuals. The reasoning behind the creation of the CNSA program, accomplishments, deployments and assessments are discussed in this paper.

Introduction

The computer world is constantly changing. In fact, one can assume that change is the only constant that can be ensured surrounding this area. As a result, traditional areas and practices of computer education must also change and adapt to make certain that institutions of education reflect the current practices and future areas of this industry [1]. Over recent years, we have seen a global initiative to format data electronically to be utilized over scalable networks, include redundancy, permit high-levels of security of data being stored or exchanged, and archived properly to allow the data to be recalled or mined at a later time.

Recognizing the need to fill the technical void within industry that computer related programs such as computer engineering, computer science, computer information science, and management information science have not addressed, Michigan Tech University has created the Computer Network System Administration (CNSA) program.

Responding to Industry's Technical Needs

The original proposal for the CNSA undergraduate program was developed by the Electrical Engineering Technology (EET) department at Michigan Tech. Their notion was to establish a program targeted on providing education in one area of the computer industry that has seemed to be overlooked in recent years, network and systems administration. To accommodate this developing program, EET structured the CNSA program with a large electrical background and incorporated several network administration and Unix courses into the curriculum. Each of the courses, like the ones offered today within the CNSA program, offered hands-on labs to accompany the recitations or lectures. The direction of the program was accurate at the time of initial development, however industry soon began looking for students who also encompassed advanced network/systems engineering and computer/network security skills. This critical feedback was a catalyst to the program's restructuring.

The reformatting did not only include the CNSA curriculum, but also included the methods, structure, and practices used in providing education for students within this program. This included the type of co-ops and internship opportunities affiliated with the program, as well as how senior research projects are formatted, offering unique opportunities with industry collaboration, and the redefining of expectations to allow the student to truly reach their potential in the field of study.

CNSA Curriculum Structure

The CNSA program has been strategically designed to offer an advanced and challenging curriculum that prepares students to become an asset within industry immediately. In order to accomplish this goal, the program has structured its curriculum to educate its students on developing solutions for problems currently facing industry, as well as those in the foreseeable future. Students are initially exposed to the fundamentals concepts regarding computer/network security and engineering before entering the intensive lab structure that does not simply reiterate the technology's uses, but rather defines how it can be used to solve real problems. This simple concept of establishing labs designed to solve problems within the field generates a significant amount of creativity from the students and forces them to think outside-the-box, which in turn helps them better learn and utilize the technology.

The curriculum of the CNSA program at Michigan Tech University offers students a comprehensive education in this unique computer/network field. The program's structure, which can be seen in figure 1, demonstrates the program's versatility of computer/network

technology and defines a recommended logical progression a student would experience within this curriculum.

Freshman Year

In the first year, students are exposed to C/C++ programming, cases and studies regarding computer cyber ethics, which includes in-depth discussions and analysis of license infringement and piracy, and computer operating systems architecture. Learning C++ is essential for students entering the fields of network/systems engineering and computer network security. This course also plays a large role in preparing students for the high-level of scripting that is required in many of the upper-level courses within the curriculum. Along with the core CNSA courses within this first year, students are also expected to complete the required calculus course, linear algebra, and fundamental electronics, which provides students a base of electronic knowledge that is crucial for diagnosing such problems within industry as power supplies and data center electrical issues.

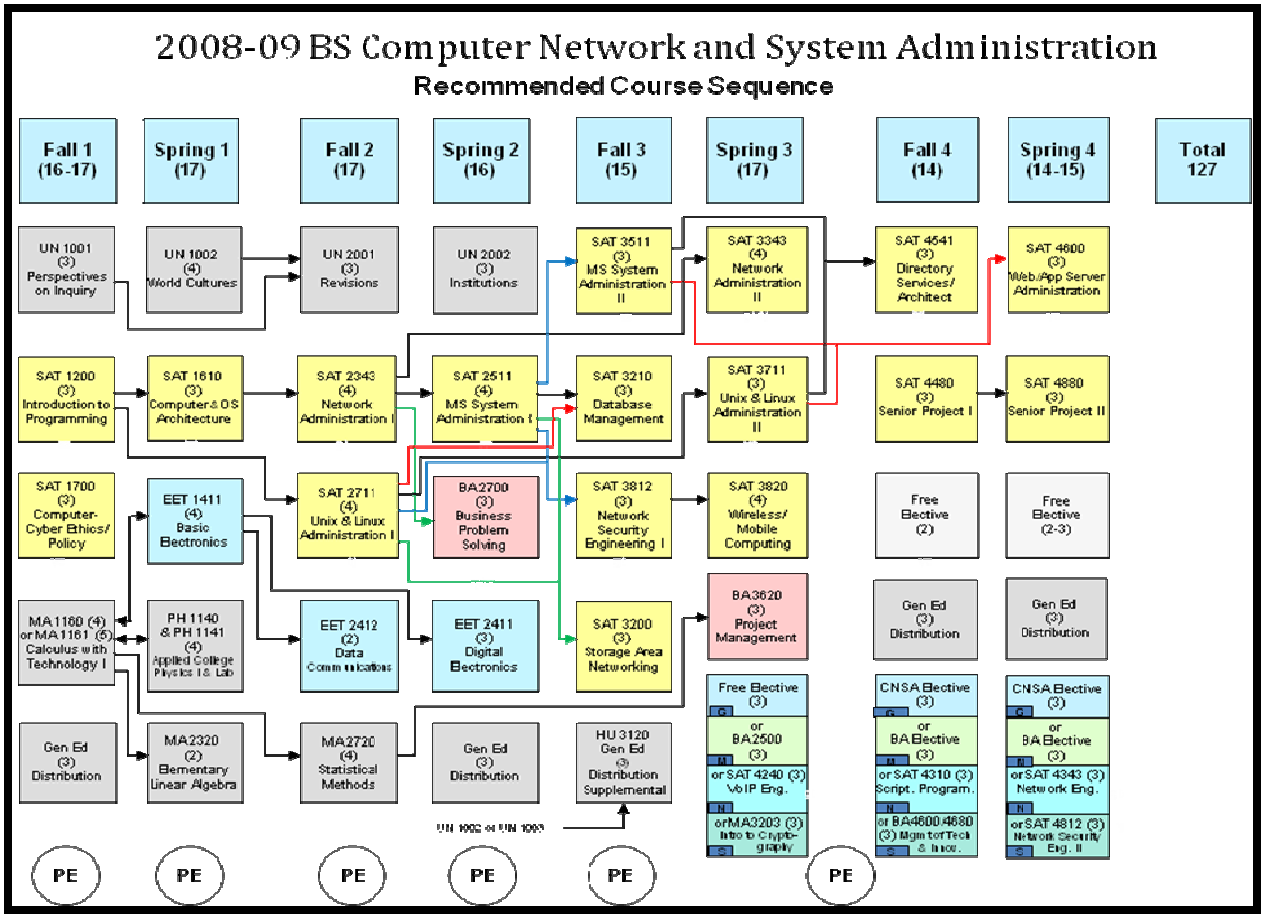

Figure 1: CNSA Undergraduate Curriculum Flow Chart

Sophomore Year
The second year of the curriculum exposes students to recitations and labs in the administration and management area of the technology. Network administration I, Unix/Linux administration I, and Microsoft system administration I prepare students for the fundamental knowledge regarding these subjects and prepares them for the more advanced topics offered at the upperclassman level. Data communications and digital electronics are also offered at this time to further enhance the students' electrical background, while statistical methods and business problem solving are also offered at this stage to increase the student's knowledge-base of statistical probability and methods/practices of solving problems relating to business within industry.

Junior Year
As a student progresses through the first two years of the program, they have completed a large portion of the fundamental coursework within the curriculum. Students have also allocated a great deal of time completing labs for each. Therefore the third year in the curriculum offers much more advanced topics and labs in the areas of network administration, Unix/Linux administration, and Microsoft administration. In addition, the student enters courses covering the conceptual and practical applications of wireless mobile computing, database management, and storage area networking.

Quite often, it is within the third year of the program where students begin to formulate ideas of what specific areas of computer/network industry holds the highest interest for them. To encourage students in pursuing an area of interest and to gain advanced knowledge in these subject(s), the program offers three areas of expertise to coincide with its existing program of study. Each of these areas has been strategically designed to offer students a focus within the following realms:

- Network/Systems Engineering – Focuses on network/systems engineering and green computing
- Network/Computer Security – Focuses on advanced network/computer security
- Technical Operations Management – Focuses on the managerial aspect of technical solutions

A fourth area, or "General", has also been established to allow students to draw from any of the existing three areas of focus to complete department requirements.

A lab intensive curriculum, the CNSA program combines theory with practical applications. Labs associated with the core curriculum include critical computer/network technology areas, such as advanced network engineering, wireless and mobile technologies, Linux/Unix administration, directory services architecture, computer/network security engineering, storage area networks, and VoIP engineering.

Senior Year
The last year of the undergraduate curriculum has been designed for students to complete the required courses of the CNSA program, which includes a two semester senior project. The

courses of directory services architecture and web application server administration, which focuses on the developing Internet Information Server (IIS) and Apache implementation, along with completion of students' chosen area of focus are completed at this time. Students also choose and develop a research topic throughout the course of this academic year, which is discussed in more detail later in this paper.

Student Co-ops and Internships

Since its inception, the CNSA program has made a strong effort to establish significant co-ops and internships for its students. Students experiencing internships and co-ops are very important to the CNSA program for several reasons. First, it provides a tremendous real-world experience to the student, which is seen as a benefit to future employers and enhances students' confidence within their field of choices. Secondly, it helps the student attain an excellent preview of a possible profession to help them in making a better educated decision towards their career path [2].

Internships and co-ops affiliated with the CNSA program are all paid positions and stem from industries such as the automobile industry, health care sector, and United States government. Figure 2 shows six of the students who were recently on a co-op within the Los Alamos National Lab. Below is an abbreviated list of companies and organizations that have established co-ops and internships with the CNSA program:

- Camera-Corner Connecting Point
- Ford Motor Co.
- Harley-Davidson
- Los Alamos National Lab (LANL)
- Marshfield Clinic
- Sentry Insurance
- Toyota

Figure 2: CNSA Students Co-op at Los Alamos National Lab

Co-ops and internships associated with the CNSA program are very competitive and students wishing to qualify must be in junior or senior standing with respect to earned credits within the program. Students must also own a GPA of 3.3 or higher. In addition, all students participating in this process must complete a written report that; defines and describes their role within the organization during the co-op or internship, describe student's responsibilities and projects throughout the co-op/internship experience, accurately identify and describe the technology they have utilized within the co-op/internship, and define how this experience has helped prepare them from industry. Included within this report is a mandatory evaluation of the student's performance by his/her supervisor(s) at the co-op/internship site. Having both the view of the student and their respective supervisor(s) permits the CNSA faculty the opportunity to fully evaluate the student's co-op/internship experience, along with being able to gauge how well the program is preparing students to enter the field.

Final Project and its Collaborative Design

It is no secret that industry highly recruits individuals who have exceptional technical skills that are accompanied by strong financial and team-oriented traits as well. Essentially these are persons are often referred to having obtained the "complete package" since they are able to successfully solve complex technical problems, communicate with both technical and non-technical personnel, and carry-out financial obligations as well. The CNSA program at Michigan Tech University has designed the two-semester required senior-project to adhere to these attributes.

Senior projects have become an integral portion of the CNSA program. The senior project courses are structured as a capstone course requiring the application of knowledge of previous courses, while introducing students to new concepts and research. These projects also formulate a collaboration between the program and industry, as research is directed at solving problems for industry. Table 1 displays a few of the senior projects that were completed over the past year.

Table 1: Brief List of CNSA Senior-Project and Industry Sectors/Affiliates

1. Security Penetration Testing & Network Assessment – Health Care Sector
2. Wireless Security Authentication Design & Implementation – Academic Institution
3. RFID Development and Integration – Harley-Davidson
4. Design and Implementation of Open-Source VoIP with Health Care Institution
5. Developing and Deploying Multicasting Radio Stream – Internet2
6. Advanced Routing Protocols and Encryption – Internet Service Provider

All projects are team-oriented, encompass a faculty advisor, require weekly progress reports, and culminate with a final report and oral presentation. To encourage project communication between team members, advisor and industry sponsors; students are expected to create a dedicated web page for the project that at a minimum must contain a project wiki, which permits only authorized individuals to view its information, and a blogging application. In

addition to helping facilitate project communication, this format has also proven to enhance the documentation of project details, such as detailed network diagrams, organizing programming and scripting code for viewing, and displaying accurate project budget information.

Since students who are technically inclined often find it difficult to articulate their ideas to those who are non technical in that area of study [3], it becomes critical to prepare students in public speaking. To accomplish this, students enrolled in senior projects are expected to give one presentation a month to faculty and other teams regarding their project. Students are expected to dress either business casual or business formal and must present using PowerPoint or equivalent software. Students and faculty can then ask questions or provide comments regarding the content of the presentation. Each of the presentations are recorded and given back to the team with individual comments to each member provided by the faculty. Suggestions such as slow down speech, provide more eye contact to audience, spend more time validating the research problem that you are solving, are given to the students to help them better articulate their research. As a result of this process, students have shown a remarkable improvement within their public speaking skills that is apparent on the video recording, as well as from industry personnel who compare our students to other technical programs. The presentations also seem to help the teams better formulate the goal of their research since they must begin discussing the project and its intentions at the beginning of the project.

In addition to the technical research, public speaking and problem solving, students also have a significant financial obligation throughout the project. All technical recommendations that are provided by the team must be accompanied with financial research that validates the proposal. This is most often completed through ROI (Return on Investment) analysis. Students must also maintain the internal project budget that provides updated information on the equipment or service fees related to the project. Each of these financial aspects aids the students in developing a more extensive economic background within the technical field.

CNSA Program Assessment

There are several ways in which we can currently assess the restructuring of the CNSA program. One method is through student enrollment. A positive trend within this statistic often provides a good indication that the program offers a reputable education within significant areas of industry. As Table 2 indicates, student enrollment has steadily increased over the restructuring of the curriculum to offer a more definitive network engineering and computer/network security dimension, while further developing and enhancing the network/system administration.

Table 2: CNSA Enrolled Students by Year

Year	*Students*
2003-2004	**22**
2004-2005	**63**
2005-2006	**101**
2006-2007	**132**
2007-2008	**156**

A second method of assessment that can be conducted to help determine the effects of the revised CNSA program is student retention. This statistic can provide a variety of meaning and interpretation, so it should be used carefully when used as an analysis tool [4]. Reduction in a program's student retention is usually an indicator that students may have lost interest within the program and its content, or perhaps they don't view the program as being able to significantly achieve their career path. While a positive or increased retention rate would signal that the program is engaging and entails an optimistic career path for those enrolled. The CNSA program did initially struggle with this statistic as can be seen in Table 3, however the revised program structure, which was completed in the fall of 2006, has significantly increased this statistic.

Table 3: CNSA Freshman to Sophomore Retention Percentages by Year

Year	*Percentage of Students Retained*
2003-2004	**0%**
2004-2005	**70.0%**
2005-2006	**63.2%**
2006-2007	**70.0%**
2007-2008	**77.1%**

A third assessment tool is a combination of the percentage of students that have secured positions prior to graduation and graduates' starting salaries. CNSA students currently have a 99.92% placement for graduates of the program prior to graduation. In addition, the starting salary for CNSA students in spring of 2008 averaged $55,700 compared to 2005's average of $44,500. The main reason for this significant increase is due to the type of jobs that CNSA students are qualified to accept. Prior to the restructuring of the curriculum, careers offered to students within the program were usually limited to network or systems administrator positions. These positions also have lower starting salaries than network/systems engineering positions or computer/network security positions. When the CNSA program restructured its curriculum to include network/systems engineering, computer/network security, and technical operations management, this resulted in both an increase of graduate placement within industry, as well as the average starting salaries for students.

Below is an abbreviated list of the types of positions graduates from the CNSA program have recently accepted:

- E-commerce developer
- Integration engineer
- Network engineer
- Optical engineer
- Security analyst
- Systems engineer

Conclusion

The CNSA program at Michigan Tech University has made great strides to ensure that its uniquely structured program accurately reflects industry's and best prepares its students to enter the computing and networking fields. In order to accomplish this goal, the program has restructured its curriculum, altered the process and methods of how it conducts senior research projects, and redefined its co-op and internship process. As a result, student enrollment within the program has continued to increase, student retention has improved, and graduates are entering the field with a higher placement level with average starting salaries.

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Biography

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