2006-563: THE EVOLUTION OF A TECHNICAL CURRICULUM

Ron McKean, Ferris State University

Ron McKean – Is serving as Interim Associate Dean / Associate Professor in the College of Technology at Ferris State University (Big Rapids, MI). His academic experience includes 15 years as faculty (four as Department Chair) in the EET & CNS department. During this time, he has championed several curriculum initiatives including the BS Computer Networks and Systems. Prior to academics, he worked 14 years as an Electrical Engineer, Engineering Technical Manager, and Principle Investigator/Project Engineer. He holds a MSEE from the University of Michigan.

The Evolution of a Technical Curriculum

Curriculum development is one of the most exciting, rewarding and challenging aspects of higher education. Quickly changing technologies and economic factors require education that is agile and creative. Establishing a new curriculum is often difficult due to procedural steps, limited resources and internal politics. Once in place, it needs to maintain technical currency as well as attractiveness to the student and employer.

This paper presents a history documenting the birth of a unique degree program and its subsequent evolution to remain effective in a very dynamic and technical world. This story reveals on-going challenges, creative responses, and lessons learned. Analogous to the natural world, survival depends upon continuous improvement. Not only is an educational program judged by economic viability but also an ethical responsibility to meet its educational goals. Most importantly, the undergraduate educational experience must lay a foundation for a successful career as well as a valued societal member. The interaction of curricula, resources, marketing, technology and other factors are also discussed.

While *assessment* and *continuous improvement* are important for external accreditations and internal reviews; it is helpful to look back and examine their long-term benefits. These methods provide information that generally indicates needs for improving quality in the form of methods, facilities or content. However, real resource constraints usually contend with quality. Quality education requires effort not only by the student but also faculty and administration. Sacrificing depth and experience to placate economics of low cost and high volume will over time undermine educational goals and industrial needs. The importance of faculty ownership and industry involvement to enable quality and responsive education cannot be under-stated. Creative solutions can overcome resource shortages and enhance the success of technical programs. This documentary is intended to help develop principles of common wisdom for initiating and evolving technical degrees in a resource challenged environment.

The subject curriculum…

The Bachelor of Science in Computer Networks and Systems (CNS) will serve as the case study in this paper. Although its concept can be traced to 1991, next fall will mark only the tenth year of its actual existence at Ferris State University[1].

A fertile environment…

Throughout the 1990's domestic technology and manufacturing flourished. The explosion of technology and the ability to practically realize the most sophisticated applications in affordable products created excitement and expectations not only for engineers but also marketers, executives, stock holders and especially consumers. Embedded applications were being developed by both large and small companies for every industrial, commercial, consumer, medical, and military application. Personal Computer technologies were incorporated into widespread instrumentation and control systems applications. Networked computer communications were transforming both technology and society. The rate of technological advancement and innovation was being experienced more than ever before. Smaller and faster electronics provided performance and features that could not be imagined a decade earlier. Emerging operating systems were just beginning to exploit electronic hardware to enable sophisticated user interfaces, multi-tasking, advanced memory handling, security and a wealth of application tools. New programming languages emphasizing object-oriented techniques and cross platform applications were finding acceptance. Smaller, smarter and more diverse sensors became available to detect bio-chemical, optical, magnetic and physical behaviors. Standardized networking protocols opened new markets for hardware and application development.

Technology Circa 1991[2] *-*

- *Windows 3.0 current*
- *MSDOS 5.0 released*
- *Microsoft leaves OS/2partnership with IBM to continue independent Windows NT development*
- *Intel Introduces the 486SX chip*
- *Sun Microsystems launches "the Green Project" that will result in JAVA*
- *Linux is introduced by Linus Torvald*
- *World Wide Web is launched.*
- *Embedded Microprocessors Development Strong*

Seeds of creativity...

As Internet, local networks, embedded intelligence, and computer control applications merged, industry encountered a shortage of qualified technical staffing. Employment searches for engineers and computer scientists with cross-discipline experience were widespread. Electrical engineers typically lacked formal software education. Computer science graduates were deficient in digital, microprocessor and other hardware based skills. Both groups lacked training in network design or implementation. Ferris State University's Electronics faculty perceived this as an opportunity to introduce a new Bachelor of Science degree that would provide graduates with knowledge in computer technologies that spanned digital electronics, microprocessors, networks, and control software.

As the degree concept was introduced, it met mixed reviews within the university. Although not all department faculty were enthusiastic, it found general support. Also, industrial advisors for the existing BS EET program were highly supportive of introducing this new degree.

Intelligent design - the curricular genetics...

The educational outcome for this degree was to graduate students prepared to take leadership roles in the application, development and management of these newly converging technologies. The graduates would have an exceptional technical understanding enabling them to meet the challenges of an ever-evolving digital world.

Curriculum components were assembled to provide a solid foundation in basic electronics, digital/microprocessor theory and design, systems integration, real-time software and operating systems, networking and project management. The curriculum would follow Ferris State's strong tradition in technology degrees that emphasized hands-on education re-enforcing applied theory. The curriculum largely consisted of existing courses in Electrical/Electronics, Computer Information Systems and Computer Science. New courses were necessary for more unique topics such as *Real-time Operating Systems* and *Network Theory and Test*. A *PC Data Acquisition and Control* course was also introduced to replace a more traditional *Sensors and Transducer* course. Observing the historically proven benefits of internship and a capstone project course, these were also included in the curriculum.

The course selection targeted graduates for employment at companies that where technically based and largely focused on development and manufacturing. By the late 1990's the skills most in demand included many still popular today.

- Software developers (C, C++, Java, and Assembler)
- Networking and Internet technologies
- Embedded systems development
- Hardware/software development and debugging
- Project management

At a time when new jobs in these fields were outpacing graduates at a 4:1 rate, many positions were being filled with those who had limited on-the-job experience. Those were days in which the networking, embedded and software markets were at their peaks.

Technology Circa 1993[3] -

- *Windows 3.1 running on DOS*
- *First Intel Pentiums shipped*
- *Wired magazine published its first issue (March)*
- *CERN releases World Wide Web into the public domain*
- *White House access to world wide web established*
- *Embedded microprocessors development strong*

Establishing viability in a harsh environment...

As the concept was formally documented, the initial layout of the curriculum and resource plan was developed. When a curriculum proposal is completed, it must ride the rough seas necessary for approval. The path traverses linearly through the curriculum committees (department, college and university) before it goes before the faculty academic senate. The approval process also includes the Deans, the university library, all affected departments and the Vice President of Academic Affairs.

Recognizing the environment of downsizing and cut-backs that existed on campus at that time, every effort was made to demonstrate the viability of the new degree, its value to the University and its importance to industry. It was important that initial implementation of the curriculum require minimum resources and represent a cooperative effort by including departments in colleges across campus.

Before proceeding to the committees with a proposal, we began to work across the campus both to establish a stronger degree and to better the chance of passage. Important fronts were: our own College of Technology, the College of Business – Computer Information Systems department, and the College of Arts and Science – Mathematics department (Computer Science minor).

Although the outward indicators (employment ads, journal articles, market predictors, etc.) all pointed to the viability of the degree and success of the graduate, a more in-depth market study was requested.

Ferris State's Marketing Department conducted the survey as part of a senior class project. The survey included 58 Michigan and 101 out of state companies with greater than 100 employees and who hired Electrical Engineers and / or Computer Science graduates. The results successfully demonstrated demand for both the degree and the graduates.

Industry Survey (1993)

Surveyed Industries:

Aerospace (10)	Health (4)
Automotive (26)	Manufacturing (43)
Computer (35)	Other industries (41)

Results from 58 Michigan and 101 out of state companies:

- Degree Need (Strong 58.5%, Moderate 34.0%)
- Graduate Hire (Definite 51.6%, Consider 42.8%)

A national search was also performed to establish the uniqueness of both this degree name Computer Networks and Systems and content. Although the content of the FSU-CNS program remains fairly distinct in content, a simple *google* search will verify that the degree title is now quite popular in many forms.

Technology Circa 1995/6 - [4]

- *Windows 95 introduced running on DOS*
- *Windows NT4.0 available for high-end*
- *Microsoft CE v1.0 released*
- *Intel releases 200Mhz P6*
- *First Intel Pentium Pro Introduced*
- *Apple stock falls to less than $18/share (vs. about $70 after ten years and two stock splits)*
- *JAVA unveiled for public sale*
- *Internet now has an estimated 36,000,000 users*[5]
- *Client /server networks replacing mainframe computers.*

Early challenges for a new program…

When introduced in 1996, only partial start-up resources were had been acquired. A lab for Network Theory and Test, Control Networks and Real-Time Operating Systems had not yet been established, there was limited faculty experience in network technologies, and computers and network hardware were not yet acquired. Ambitious faculty, eager industries and a lot of politics enabled resources to become available in time to succeed.

The length of elapsed time between initial concept and actual implementation speaks for itself regarding the smoothness of the journey. Rather than present a chronology, a summary of some challenges and learned lessons is provided.

Challenge - *Pressure to create a more easily implemented BSEET minor rather than a new degree. This was seen as hindrance to evolving CNS, marketing to target students, and employment in many of the new markets.*
Solution - *Create a new program that can evolve independently from the BSEET and could attract students with interests that differ from typical EET students.*

Challenge - *Several aspects of the proposed program intruded on the perceived turf and identities of programs in other university colleges.*

- *College of Technology Deans had strong preference to industrial programs and did not actively support a computer/networking program.*
- *Mathematics (College of Arts and Science) offered a minor in Computer Science and felt the similarity in name would impede their growth. (The original proposed name for CNS was Electrical Computer Science.)*
- *Computer Information Systems-CIS (College of Business) was concerned both with program name and a perceived overlap in learning outcomes*

Solutions -

- *Change name to Computer Networks and Systems*
- *Better articulate the differences in outcomes between CIS and CNS.*
- *Include Computer Science and Computer Information Systems courses.*
- *Create a concentration track within the program with easy lead-in to a CIS minor.*
- *Establish a good relationship with CIS faculty and the College of Business administration*

Challenge - *University direction and resources at this time were very tight and consolidation was the rule. New programs, requiring new courses, faculty and resources had little chance of approval.*

Solutions -

- *Limit the new program initially to only two unique courses-*
    - *Network Theory and Test and*
    - *Real-time Operating Systems*
- *Replace an EET course with one useful to both curriculums - PC Data Acquisition & Control.*
- *Use outside expertise for specialized topics until tenure track positions could be justified and current faculty could obtain additional training. Network professionals used for adjunct teaching and guest lectures.*
- *4-Utilize an existing classroom as a temporary classroom/lab for the new courses.*
- *Obtain network equipment through industry and university donations.*

Challenge - *A separate university support staff oversees lab computers. Their charge is to maintain properly operating computers correctly configured for software and network*

applications. This was not compatible with CNS students' needs for complete hardware / operating system / software / networking access and manipulation.
Solution - *Provide the lab with unsupported older computers being cycled out of other campus computer labs. This extends the usability of the university's computer investment and provides students with computers that can be modified and applied to a variety of lab project experiences.*

Challenge - *A responsible program develops support from industries that will employ graduates. An industrial advisory group provides outside assessment of the curriculum, a window for students to the "real world", assistance in equipment acquisition, internship opportunities and a host of other benefits.*
Solution - *Acquiring members for the advisor group is an on-going effort. However, the initial group formed readily from contacts made through BSEET advisors, and those developed during surveys, conferences, seminars, etc.. Some of the best advisors came to us!*

Lessons Learned...

1. **The outcomes of the new curriculum should have employment value in multiple industries and multiple related fields within those industries.** The trade-offs between specialized and generalized curriculums are often debated on merits of college resources and productivity. Graduates will be most concerned, to receive a solid education with good employment and growth opportunities. Target industries and disciplines must be studied to determine trends and closely related fields that can grouped into a common curriculum. The result provides both broader understanding and opportunities.

2. **Decide early on the magnitude of what is to be proposed.** New curriculum can take shape as a certificate, minor, or a new degree/major. Generally, it's unwise to try to divert an existing curriculum to an entirely new direction. Unless the existing curriculum is largely recognized as obsolete or dysfunctional, only turmoil will result – no matter how good the idea is. Even minority faculty, advisors or administrators can disrupt the process and destroy the effectives of the new curriculum.

   A new degree/major with its own identity and advisor committee will provide the greatest opportunity for success. A dedicated direction enables greater agility to move the curriculum as required. The negative side is that resources may be more difficult to obtain when benefits are program specific.

3. **Involve as many in the curriculum development process as possible.** Get early buy-in from those who believe and wish to become part of a new initiative. This includes faculty, college and university level administrators, and key industry representatives.

   Since each will bring an agenda as well as value, not all should be involved equally. The principles of the initiative need to separate that which supports from that which subverts. To the extent possible, none should be threatened or eliminated from some participation and benefit of the initiative.

For example, an upper-level administrator from the University's network and computer support division (Information Services) has been on the CNS advisor committee since it was initially formed. Our benefit is better access to campus network equipment donation, access to cycled out computers and knowledgeable computer and network professionals. Their benefits include access to knowledgeable (CNS) students as part-time employees, access to graduates for career employment, academic courses for staff development and, at times, use of program equipment and facilities.

4. **Use existing resources to the fully extent possible.** This makes best economic sense for everyone. Wise use of resources will allow future initiatives to be pursued.

5. **Be creative in acquiring equipment and supplies. Industry donations as well as second hand university equipment.** Get the maximum amount of reuse possible from equipment and materials available. Keep in regular contact with computer and network support staff. Encourage part-time hire of talented program students in these areas.

   Another excellent resource is often created through student internship. Good interns can impress a company to donate and seek greater program involvement.

6. **Form an industrial advisor committee as soon as possible.** Industry support is key to the success of any degree program. Industry is relied on for donations (equipment, scholarship, cash, etc.), advising and often for clout. Another important benefit is realized by graduates in the form of career and placement opportunities. Other benefits afforded through industry include guest speakers, tours, adjunct faculty, senior project sponsorship and internships.

Critical Survival Needs: Advisors, Faculty, and Curriculum....

When the program launched in 1996, an advisor board was already in formation. The goal was to provide equal representation of companies whose major interests were in embedded systems, software, and networks. The full extent of the market, however, was yet to be revealed.

Although the program was well positioned to place graduates in these three primary technology areas, the employers were generally envisioned as those whose product was technology related. We anticipated companies that sold, developed, or manufactured technical products to be interested in the CNS graduates. All had substantial needs for employees with knowledge in these associated technologies.

A very pleasant surprise was realized as we were approached from industries that depended on computers and network related technologies to competitively sell services. These included companies such as large retail chains, insurance companies and banks.

These companies were attracted by the extensive technical core of the curriculum and its emphasis on applied theory. They perceived our graduates to be capable of not only developing software and implementing networks, but also having better aptitudes for interfacing, troubleshooting and developing solutions to various technical challenges.

Networking and computer technologies quickly became the strongest interest area of entering students. This was further evidenced by the selection of the CIS concentration/minor by the majority of CNS students.

Technically strong, network savvy graduates with software application development skills have demonstrated wide career potential. While industry outsourcing has increased and debate continues on the cost and sufficiency of domestic engineers, CNS graduate hiring remains consistently strong. This can be attributed to their abilities to traverse embedded electronics, computer systems, software development and network implementation, administration and management technologies. Another fundamental reason for their agility is a result of their strong core technical knowledge and ability to apply this knowledge.

Millennial Turbulence in Technologies –

1999 – Y2K fears rule hiring –
Cobol programmers hot in the market!

2000 – Out sourcing hits mainstream.
Tom Peters is quoted in the Wall Street Journal that "… as many as 90 % of today's American white collar and clerical jobs could be outsourced in the next 10 to 15 years" [6]
First off-shoring would be to English speaking countries and then to countries such as India and China.

2000 – 17,000 dot-com jobs eliminated (Jan -Oct.)

2001 – Estimated 226,185 jobs eliminated. -
Reported lose from large companies in 4th quarter of 2000... but labor market still tight.[7]

2002 – Estimated 26,000 Engineers unemployed[8]

2003 – Up to one million visas issued for high tech jobs.
The motivation is challenged. Is it due to a domestic shortage or just replacement of high paid US professional with low cost foreign workers[9]

2006 – H1 B visas limits are again raised
After a temporary lowering following the dot-com drop of 2000, the government has again increased it limits.

Evolution of the curriculum …

It soon became very clear that the networking aspect of the program would be most important for graduate employment and industry need. Over the next several years, economic and technology trends have supported this early discovery.

Adjusting the curriculum for stronger networking would require an increase in networking facilities, course offerings, and faculty qualifications. A chronology of these achievements is now presented.

When CNS launched in 1996, the core curriculum contained only two dedicated networks courses.

- ISYS 410 Local Area Networks – a CIS course with very limited hands-on.

- ECNS 321 Network Theory and Test – addressed WAN issues using multiple operating systems and network configurations. Various network analysis software was also applied within the course.

Both of these courses were taken by students in their third year.

Taking the first steps....

The first significant enhancement to networking curriculum came in 2000. Thanks to furniture and facility upgrade funding by the university and industry donation, a quality network lab was in place. A strong industry advising team was also in-place and active. Need was indicated from both embedded and industrial automation interests, to include a broader understanding of network communications. As a result a course was introduced – Control Networks.

The objectives of this course were to provide knowledge of token passing schemes, popular implementations of industrial control networks and architectures, and embedded implementations of networks including CAN and TCP/IP.

The course represented continuous challenge to teach due to very diverse and current topic matter. As a result, industrial documentation combined with internet resources and instructor study notes were relied upon heavily to supplement a more general networking text. Guest lecturers from industry and field trips also added a great deal of interest to the course. The course also included a lab to enable student's hands-on experience.

Developing a strong foundation...

Still, a major drawback in the program was lack of a coordinated coursework that could establish a solid understanding of networking early in the curriculum. At this point only one dedicated network course was required in the first two years of the program – Network Administration (evolved from the original CIS course - Local Area Networks).

Most of 2001 was spent investigating means to develop and maintain a comprehensive foundation in networks, providing both quality classroom lecture and laboratory implementation. The chosen solution was to implement the first four semesters in the Cisco Networking Academy. Each Cisco course is encapsulated within a CNS course. This enables supplemental materials to be presented and greater program-level oversight for student evaluation.

This move represented the single greatest step in the evolution of the curriculum. Resulting accomplishments include:

- Quality curriculum with computer enhanced delivery
- Emphasis on a quality laboratory experience
- Technical currency provided through Cisco
- Large discounts on network equipment, and analysis tools
- Design, documentation and simulation software
- Faculty training provided to assure faculty currency

- Strong community infrastructure for support, student opportunity, and professional contacts.
- Excellent marketing resource for high school and community college articulation.

Program growth had now justified a new faculty hire with expertise and experience in computer and networking technologies. Coupled with on-going training, faculty expertise had increased significantly. This not only strengthened program quality, but also enabled us to do the Cisco initiative.

To accommodate the additional networks courses, others needed to be removed from the curriculum. University standards on general education and required physics and math courses resulted in tough decisions. Assessment feedback (current students, graduates, advisors, employers and current technology trends all indicated that CNS students were receiving more electronics than what the vast majority would require for targeted program outcomes. As a result, eliminated courses included an introductory technical preparation course, an advanced analog electronics course and a circuit based communication course. Also, since network setup and use of administrative tools for both UNIX and Windows were incorporated into existing CNS lab assignments, a CIS based network administration course was eliminated.

By involving industry partners in this decision, we were able to meet costs associated with the new courses were offset through donations. Donations included upfront costs, ongoing lab sponsorship, and a good quantity of networking tools. The university also proved funds to supplement curriculum change costs. Four faculty have since been trained with primary funding from Exceptional Merit Grant awards – sponsored through the Ferris Foundation.

Opportunities through change...

By 2003 the department was undergoing significant changes. Several faculty retired, providing opportunity to bring fresh talent into the program. In addition, the entire department facilities were being remodeled. Change equals opportunity.

Through a little crafty floor planning, an existing storage/repair room converted very nicely into an advanced networking laboratory. Also, a lecture/operating systems lab was created with minor conversions to an existing lecture room. Since most labs were receiving new furniture, the best of the furnishing were cleaned, modified and reassigned to the new lab spaces.

Feedback from industry, graduates and technology trends was also indicated the need for a specialized industrial networking course was no longer important. Many industrial applications were moving over to TCP/IP or CAN protocols. As a result, the Control Networks course was converted to a Wireless Networks course. Although wireless theory and practice occupy most of the course outline, some introductory theory on cellular phones and global positioning is also included. Course development was performed through one of our new faculty with extensive experience in these technologies. The Wireless Networks course was first implemented in Winter semester 2005.

CAN topics and applications were moved into an advanced digital course, also required in the program.

Latest implementations...

Again, feedback from industry, graduates and technology trends indicated that network security knowledge is important. Data security is now implemented to some level on every network. Rather than duplicate courses whose objectives are primarily implementing network security, a new course was developed that follows the technical character of the CNS program. This course examines the various forms of intrusions and malicious software. How it infects, spreads, and operated is covered. The intent is to provide students a fundamental technical understanding that can be applied to better understand prevention, cure, and forensics. Winter 2006 was the first offerings of the course: Network Security Theory and Technology.

1996 Network Courses	
ISYS 410 Local Area Networks	A CIS course focused on the essentials of understanding and implementing LANs.
ECNS 321 Network Theory and Test	CNS course that provides deeper theory of networking emphasizing WAN technologies. Various network-based projects are performed using Windows, Unix and Linux operating systems and hardware and software analysis tools.
Resources	No dedicated labs. A lecture room was setup for computer stations for lab assignments.
Faculty	Two full-time faculty and adjuncts with strong network expertise were assigned to ECNS courses.

2000 – Network Courses	
ISYS 310 Network Administration	A CIS course evolved emphasizing LAN and Windows administration.
ECNS 312 Control Networks	New course developed to provided a better understanding of LAN, industrial networks and CAN implementation.
ECNS 321 Network Theory and Test	As described above.
Resources	By 1998 the CNS program had acquired university and industrial funding to create a nicely furnished and equipped lab for network courses.
Faculty	Two full-time faculty and adjuncts with strong network expertise were assigned to ECNS courses.

2002 – Network Courses	
ECNS 115 Networks 1 ECNS 125 Networks 2 ECNS 215 Networks 3 ECNS 225 Networks 4	Cisco Networking Academy series that provided quality curriculum and hands on labs. The curriculum is very complete for both LAN and covers concepts a several WAN technologies. Structured labs now include much greater router emphasis. A

	large investment on network devices and hardware analysis tools is made.
ECNS 315 Network Theory and Test	Course materials ratchet up several notches from old ECNS 321 due to enhanced student background courses. Greater lab emphasis on WAN network implementations.
ECNS 325 Control Networks	Moved after Network Theory and Test, this course is able to concentrate on more in-depth materials. However, a formal course lab was sacrificed to enable curriculum enhancement.
Resources	The original networks lab is now dedicated to the Networks 1-4 courses. The upper level network lab for Network Theory and Test struggles as it is moved to smaller lab facilities. (Remedied in 2003)
Faculty	A third faculty with expertise in computers and networks is added for CNS courses. Three faculty with expertise specific to CNS are now in the department.

2005/06 – Network Courses	
ECNS 115 Networks 1 ECNS 125 Networks 2 ECNS 215 Networks 3 ECNS 225 Networks 4	Cisco Networking Academy series underwent a major revision resulting in higher quality curriculum and introducing newer in higher –end topics. Lab equipment for these courses is also upgraded through industry sponsorship and equipment donation. A net simulation and design software program available for student also improves significantly.
ECNS 315 Network Theory and Test	Greater lab emphasis on WAN network implementations.
ECNS 325 Wireless Networks	The Control Networks course topics are significantly modified to reflect graduate needs for greater wireless network knowledge. GPS and Cellular theory are also introduced. As industry shifts to primarily TCP/IP and other non-proprietary protocols, the material is omitted. CAN topics moved to digital courses. Course also raises level of materials.
ECNS 425 Network Security Theory and Technology	Provides a greater technical knowledge of data security hazards. The course examines various forms of intrusions and malicious software. How it infects, spreads, and operates. The objective is to provide students a fundamental understanding that can be applied to better understand prevention, cure, and forensics.
Resources	A new Networks lab is now available for the Network Theory and Test course. Another smaller lab is also available for Real-time Operating systems.
Faculty	Another faculty hired full-time with expertise in wireless technologies and related embedded applications added to the department.

Its not just networks that has evolved....

Networks have certainly been to fastest growing and evolving aspect of this curriculum. This is due largely to necessity. As the weakest asset of a new program and since major learning objectives were linked to networking, its growth was critical to the program's survival.

However, software and hardware components of the curriculum have also changed notably in response to advancing technology and industry need.

Assembly Language - When CNS was first introduced Assembly Language existed as a separate course. While assembly is still important for *low level* control, advancements in circuit technology have enabled greater usage of higher level programming, such as C and C++. In response assembly language emphasis has been reduced and absorbed into digital/microprocessor courses.

Basic – BASIC has maintained its relevance in industry and has evolved from various forms into VB.net where it is today.

C/C++ - C and C++ are considered the primary structured languages in industry. Early curriculums required two semesters of C/C++. The first course is taught by CNS faculty to ensure technical application to embedded environments. The lecture only High Level Programming course is required for both CNS and EET majors. A concurrent, application lab is mandatory for CNS and optional for EET majors. Following industry trends, language emphasis has shifted from C to the more object oriented C++.

Recent curricular changes have eliminated the second semester of C/C++. Interested students are encouraged to either take a second semester of C++ and/or advanced JAVA as elective courses within the program. Additionally, a good deal of programming experience is provided by the Real-Time Operating Systems course.

Real-Time Operating Systems – This distinctive course merges microprocessor technology with features and designs of various operating systems (e.g. UNIX/LINUX, Windows, Solaris, and QNX). Real-time features are emphasized. Labs demonstrate OS features and implement multi tasking applications.

The original operating system used for labs and real-time examples was a DOS based OS called uC/OS[10]. Feedback urging better understanding of UNIX environments, developing OS applications and need for a more comprehensive RTOS, resulted in a switch over to QNX. Establishing a QNX in Education partnership with QNX Software Systems also enabled low cost access to QNX products and services.

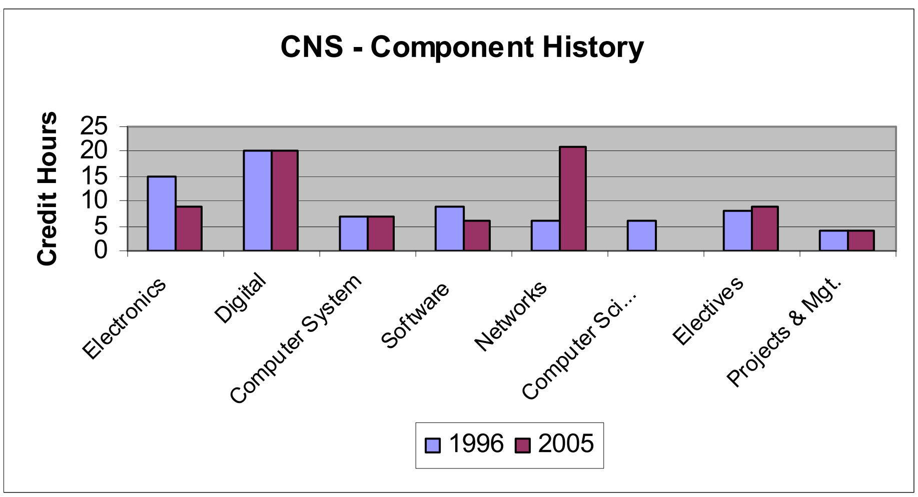
PC Data Acquisition and Control – Originally based on an EET sensors course, it was enhanced to also incorporate computer based acquisition and control. Initially, lab applications were developed using BASIC. As instrumentation software emerged in industry for control and simulation, the application software for this course also evolved. Functionality provided by

National Instrument's LabView matched our needs very well. Also, LabView's popularity in industry has been an advantage for both the program and students.

Foundation Electronics – Industry has continuously reinforced the value of a strong electronics foundation. This is, in fact, one of the defining aspects of CNS. The strategy to utilize existing EET courses resulted in the traditional DC, AC, and Electronics Circuits sequence being inherited by CNS. Although this provided a very efficient use of course resources, the sequence was not efficient for in meeting CNS education goals.

This year, a new method of teaching foundation electronics was introduced into both the CNS and EET curriculums[11]. This new implementation eliminates the rigid sequencing of DC, AC, and Circuits. Instead, topics are blended to create a greater variety and interest in the courses. The new curriculum reduced electronic foundation courses for CNS students by 3 credits. The significance of this efficiency is that it created *space* for a new senior level course with valuable content while retaining shared EET and CNS foundation courses.

Digital Course Sequence – Recognizing a thirty year divide between current digital technology and traditional digital education, this course sequence was recently modernized. An EET/CNS faculty member utilized a sabbatical to gather information and coordinate the development of new course and lab outlines. Also, grant and donation opportunities were realized to identify and obtain necessary lab equipment. The result is a more efficient and valuable learning experience for students. [12]



Current initiatives and future goals...

Continuous improvement of the Computer Networks and Systems Future curriculum will result from actively gathering and analyzing input from industry, alumni, students, and associated trends. The primary catalysts in the evolution of the program will be advancing technology and marketing.

Technology driven change will necessitate the pruning and compacting of less important topics to assure exposure and foundation in the most relevant and latest technologies. Existing courses will be modified and new courses introduced. Labs, equipment, software, and devices will continuously evolve to reflect modern applications. Network, data security, RFID, wireless, control systems, and software technologies will undoubtedly increase prevalence in the curriculum. Opportunity for international study will also better prepare graduates of the future.

Market driven change will result from increasing competition that will continue to push envelopes of educational experiences, efficiencies as well as the delivery and packaging of the program. Creative bundling of minors accelerated graduate degrees and study abroad options will add value. Intriguing projects that engage students and industry will also add appeal and exposure. Quality related costs will need to be justified.

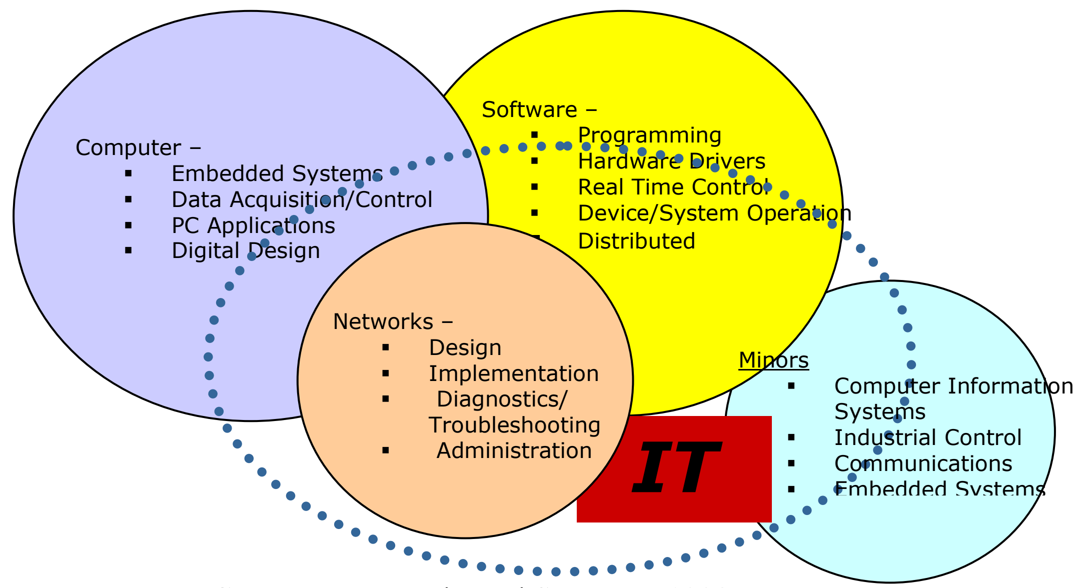
Accountability to students extends beyond the award of a degree and requires consideration of both the cost and value of education. Change that compromises quality for costs reduction is short term bliss. A successful program will adopt innovation to enhance value while being sensitive and responsible to minimize costs. The overriding goal should remain focused on the most important indicator of value - graduate success.

Common wisdom...

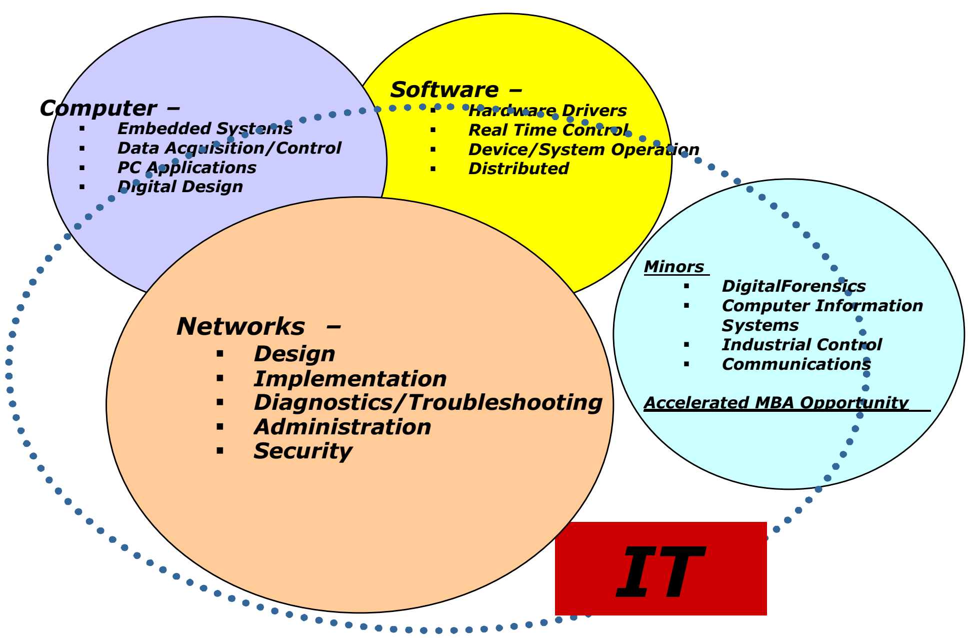
For a curriculum to stay relevant for students, graduates and employers it must:

1. Focus on continuous improvement in achieving learning goals that add value to the graduate.
2. All curriculum change should target quality. Economics and competition can drive curriculum toward a short sighted, downward spiral of compromise. Resist this path! Instead, strive to minimize costs through creative and resourceful solutions.
3. Be agile to keep curriculum current and efficient. Continuous pruning and consolidation of course content will help maintain currency and create room for new courses. A curriculum that addresses topics of current relevance will attract students and industry support. Beware! It is a rare faculty group without at least one whiner who bog agility. Get past it.
4. Encourage and enable faculty to strive for personal and professional development. Pursuing expertise in areas of personal interest can foster future opportunities and improve morale.
5. Be proactive to involve the right industries and appropriate representatives into your program areas. Attitude, influence, ideas, and energy of industrial partners will make the difference in the success of a program.
6. Look for opportunities to be inclusive of multiple disciplines within a program. The added breadth will not only benefit students but also create opportunities for interaction with industry and for program growth.
7. Often it is better to try a viable and progressive idea expediently, then to miss opportunity by insisting on extensive justifications that result in wasted energy, faded enthusiasm and self defeating hindrances. Be prudent, but not to excess.

Finally, the long-term success of a department may lie in its ability to identify with its discipline(s) rather than its program(s). The separation will reduce anxiety related to the rise and fall of programs. This does not reduce the need for faculty ownership in programs or for program champions. However, technical advances, world economies, state and local resources, student populations and a million other factors will bring about need for change. While these changes may sometimes indicate program obsolescence, rarely will eliminate need for a discipline.



Computer Networks and Systems - 1998



Computer Networks and Systems - 2006

[1] Original memos related to development and justifications for this degree actually date back to early 1991. Formal proposals were written in 1993.
[2] http://www.computerhope.com/history/windows.htm
[3] http://www.computerhope.com/history/19902000.htm
[4] http://www.computerhope.com/history/19902000.htm
[5] http://www.internetworldstats.com/emarketing.htm
[6] Wall Street Journal- Online, August 28, 2000 Different Countries, Adjoining Cubicles, M. Clifford and M. Kripalani
[7] Wall Street Journal- Online, February 12, 2001 Still Seeking Job Seekers, J. Fields
[8] EETIMES – Online, March 15, 2003, Job For Life? No Longer, M. Quan
[9] Wall Street Journal- Online, August 11, 2003, Too Many Visas for Techies?, S.E. Ante and P. Magnusson
[10] µC/OS, The Real-Time Kernel, R & D Publications, Inc., Labrosse, Jean (revised editions available)
[11] The text (,DC/AC Circuits and Electronics: Principles & Applications; Thomson/Delmar) and associated materials were developed by Robert Herrick at Purdue University.
[12] Modernizing the Digital Sequence in EET and CNS, Clare Cook, 2005