

Systematic Development of Successful Innovative Programs

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Abstract

An analysis of national critical technologies and the grand challenges indicates that two of the most critical technologies are manufacturing, and information and communications. Also the employment opportunities in the future are for professional with background in system development or system integration. Thus it is very important to systematically analyze the industry needs and understand the expectations from the graduate before developing new programs. This paper describes two such unique graduate programs that were developed through a systematic analysis of national critical technologies, future manpower demand projections, academic and research background of our faculty, and the interests of our students. The M.S. program in Computer and Information Systems Engineering (CISE), an interdisciplinary field that integrates different aspects of computer engineering, computer science, electrical engineering, systems engineering and information systems, was implemented in fall 1997. It has since experienced a phenomenal growth in student enrollment. A Ph.D. in CISE program, which builds on the master's program as its core, has since been developed and approved for implementation.

1. Introduction

The goal of the College of Engineering, Technology and Computer Science at Tennessee State University is to offer educational programs that support the mission of the University and its governing board, which is "an educated Tennessee." It is therefore our mission to offer educational programs that will prepare our graduates for high paying future careers that address the needs of our society. This paper describes systematic development of two unique graduate programs leading to Master of Science and Ph.D. in Computer and Information Systems Engineering (CISE) and successful implementation of the master's program.

2. Background

Tennessee State University, as a comprehensive, major urban and land grant university, offers degree programs from B.S. level leading up to Ph.D. degrees through eight colleges and schools. The College of Engineering, Technology and Computer Science offers ABET accredited B.S. degree programs in Architectural Engineering, Civil Engineering, Electrical Engineering and Mechanical Engineering. It also offers a Master of Engineering and a unique Master of Science in Computer and Information Systems Engineering (M. S. in CISE), which was initiated in fall 1997. The M. S. in CISE program has since experienced a 600 % growth in student enrollment.

The College has 35 faculty members of whom 85 percent hold Ph.D. degrees. Over 50 percent of Electrical and Mechanical Engineering faculty are pursuing funded research. The College has a well-established Center for Neural Engineering that is funded by the Office of Naval Research

and six well equipped research laboratories for CISE, Computational Fluid Dynamics (CFD), Intelligent Signal Processing, Intelligent Control Systems, Probabilistic Design, and Computer Integrated Manufacturing, which are well equipped with latest computer hardware and software needed to support research. Our faculty's academic and research areas include signal and image processing, intelligent control systems, application of ANN, fuzzy logic and genetic algorithm to health monitoring and predictive maintenance of ball bearings, computer communication and network applications, intranet development, distance education, robotic applications and computer integrated manufacturing. The College has six unfilled faculty positions and expects to hire faculty to support new programs and additional research. The Department of Computer Science has ten faculty members and three have expertise in database management, software development and parallel programming.

The university offers four Ph.D. degree programs and directs funded research worth over 25 million each year through the Office of Sponsored Research. The university aspires to achieve Research University Level I status and has recently received approval to offer a Ph.D. in Computer and Information Systems Engineering. It has two state supported accomplished Centers of Excellence. It's Center of Excellence in Information Systems Engineering and Management has a NSF funded Crest Center to enhance the number of under-represented minorities with advanced degrees.

3. Need Analysis

With the mission for an "Educated Tennessee" and the goal to prepare our graduates for high paying careers, a systematic review of the following was carried out to get an understanding of educational program requirements. A review of national critical technologies, the ten hottest telecommunication technologies and the top ten Computational Technology Areas (CTA) indicates that high performance computing, computer communication and networks, information management, and computer integrated manufacturing are becoming increasingly important for scientific advancement, economic competitiveness and national security [1, 2, 3].

An analysis of local, regional and national manpower needs in future, indicates an almost 62% increase in demand for system analysts, database managers and operations research analysts from 1995 to year 2005 [4]. The national demand for computer engineers and systems analysts will double from 1995 to year 2005 [5]. These projections indicate that the demand for programmers will not grow as fast. This points to a need for a different type of program than a traditional computer science. The highest growth is in the areas of computer communications, networks and information management and a 100% increase in demand for systems analysts [6].

Further new programs must address the new skill requirements, such as, system integration, life cycle engineering approach to whole system development from need analysis to system retirement, written and oral communication, teamwork in a multicultural environment, for future careers [7, 8].

A review of position announcements by industry, research and academic institutions indicates a severe shortage and need for professionals with background in systems analysis and integration,

information management and software development. This is also reflected in almost 150,000 H-4 visas to foreigners to fill the need for information technology services [9].

The percentage of minorities and women receiving Ph.D. degrees in science and mathematics is only 3% and even lower for engineering, manufacturing or electrical engineering areas [9].

The increase in student enrolment in computer engineering programs is another indicator of the future demand.

High paying positions are generally offered by high technology industries. These industries have higher than average research and development spending, with a higher proportion of scientific and technical workers as compared to workers of all industries. They need highly trained specialists, with special background to develop systems that realize maximum benefits, to be competitive and maintain leadership role in global market.

4. Functional Requirements and Conceptual Design

A critical review of the functional requirements to address critical technology areas of computer communication and networks, computer integrated manufacturing and information management points to the need for an inter-disciplinary preparation that is computer hardware and software intensive. It also requires a holistic approach to solution of computationally extensive problems. i.e. a systems engineering or a life cycle approach to the whole system development [10, 11]. A concept model for such a graduate level program is shown in figure 1.

This program should provide a solid foundation in data structures and algorithms and software engineering along with a clear understanding of computer architecture and operating system relationships. It should provide a solid background in systems engineering approach to system development from need analysis, through identification of system functional and operational requirements, technical performance measures, preliminary and detailed design, construction and operation, and system retirement with coordination of all the activities through a system engineering management plan (SEMP). The program should also provide a strong understanding of the communication and network protocols, various transmission media, and multimedia information development, transfer and storage. This program should build upon undergraduate background in computer science, electrical and computer engineering, numerical analysis, linear algebra, probability and statistics, engineering economic and engineering design.

5. Program Development and Implementation

A review of some twenty-five programs in systems engineering, computer information systems, computer engineering and similarly named programs revealed that none of these programs addressed the needs identified in above need and functional analysis. The program described below was developed in conjunction with the computer science faculty and input from industry. The M.S. in CISE program requires 30 semester credit hours, which includes six credit hours for thesis and six credit hours of technical electives and eighteen credit hours of core courses that provide the necessary background in the areas described earlier.

Since there are no specific undergraduate programs in CISE, a careful analysis of student's undergraduate transcript is necessary to identify any prerequisite undergraduate requirements at the time of admission. For unconditional admission, student with B.S. degree in either electrical or related engineering discipline or computer science from an accredited program, must have a cumulative grade point average of 3.0 or more on a 4.0 scale and must have most of the related prerequisites as identified in Table 1. Conditional admission is granted to student who has a cumulative grade point average of 2.75 or better on a 4.0 scale or lacks some prerequisites. Students who need too many pre-requisites are recommended to complete requirements before reapplying. All students admitted conditionally, are required to complete the undergraduate prerequisite courses with a cumulative grade point average of 3.25 before they are allowed to take graduate level courses.

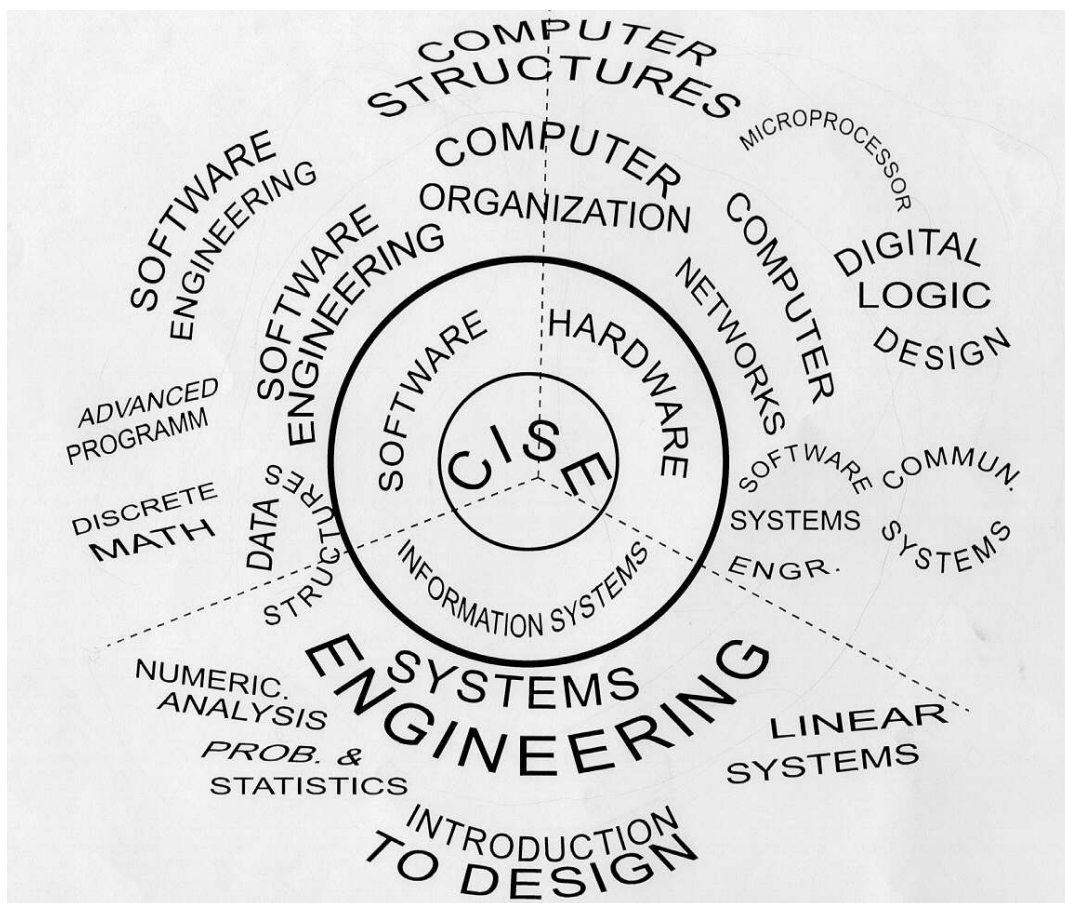


Figure 1. M.S. in CISE Concept Model

The M. S. in CISE program as shown above was implemented in fall 1997 after approval in August 1996. As is clear from the enrollment data in Table 2, this is a very popular program that is experiencing a significant growth (over 600 percent) in a very short time. Also the program attracts an exceptionally large number of minority and female students, which is very significant, as there is a severe shortage of minority and female engineers with background in these critical areas.

PROGRAM OF STUDY FOR M.S. IN CISE

Fall Semester		Cr. Hours
CISE 501	Data Structures and Algorithms	3
CISE 502	Computer Architecture & Operating Sys.	3
CISE 504	Systems Engineering	3
Spring Semester		Cr. Hours
CISE 503	Software Systems Design	3
CISE 523	Computer Commun. and Networks	3
	Elective	3
Summer		
CISE 590a	Master of Science Thesis I	3
Fall Semester		Cr. Hours
CISE 522	Computer Aided System Design	3
	Elective	3
CISE 590b	Master of Science Thesis II	3

Table 1
Pre-Requisite Evaluation Form for Admission to M.S. in CISE

Systems Engineering	Computer & Comm.	Computer Software
Applied Math	Electric Circuits	C++ Programming
Numerical Analysis	Digital Logic & Lab	Discrete Mathematics
Probab. & Statistics	Electronics & lab	Data Structures
Linear Algebra	Linear Systems	Operating Systems
Intro. to Design	Comm. Theory	Java Programming
Engr. Economics	Microprocessor	Adv. Comp. Org.
E. M. Theory	Digital Comp. Struct.	Software Engr.

Table 2
Enrollment, SCH, Courses Offered and Student Papers and Presentations

Sem. Year	F'97	S'98	F'98	S'99	F'99	S'00	F'00
Total Enrollment	6	5	22	28	29	32	38
Minority Male			2	2	1	3	5
Female	3	2	5	10	8	8	10
Others	3	3	15	16	19	21	23
Sections offered	2	2	3	5	6	5	7
SCH Generated	60	27	102	144	168	267	228
Aver. Class Enr.	10	5	11	10	9	18	11
Student Papers, & Presentation	1	1		1	1	9	6

6. Course Description

CISE 501 Data Structures and Algorithms. (3): Files and data structures used in computing such as lists, etc., techniques of storing and retrieving data such as hashing, indexing, etc., relational data-base models, SQL databases and servers, and data-base management systems. Selection and design of algorithms search and sorting techniques, pattern matching, and mathematical problems. Prerequisite: CS 320, Engr 223L, EE 306L or equivalent.

CISE 502 Computer Architecture and Operating Systems. (3): An understanding of capabilities, limitations and applications of different computer architectures of large supercomputers to smaller workstations. Basic computer resource management techniques, discussion of types of operating systems, distributed and parallel processing, real time programming and inquire-response systems. An overview of different implementations. Prerequisite: CS 411, CS 341 or EE 430 or equivalent.

CISE 503 Software Systems Design. (3): Concept of software product life cycle, software design methodologies, stages in software development, metrics and models, reliability and reusability of code, software development tools, analysis, and design validation, small team projects involving architectural design and software specifications, computer aided software engineering (CASE). Prerequisite: EE 306L and CS 304 or EE 431.

CISE 504 Systems Engineering. (3): Introduction to systems, the system design process, system analysis tools, including decision making, economic evaluation, optimization, queuing theory, statistical methods and process control concepts, design of operation feasibility, human factors, logistics and systems engineering management plan, introduction to data-base design and decision support systems. Prerequisite: Engr 223L, 320, 340 or equivalent.

CISE 506 Error Correction Codes. (3): Introduction to codes for error detection and correction, linear algebra over finite fields, bounds, perfect and quasi-perfect codes, probability of error checking, Hamming, BCH, MDS, Reed-Solomon codes, and non-linear codes. Prerequisite: CS 320, EE 350 or equivalent.

CISE 522 Computer Aided Systems Design. (3): Advanced computer-aided analysis and design tools for analysis of system properties and performance, study of structure and theory of computer aided design, software and hardware, and the small scale design of such tools. Prerequisites: EE 310, 310L, CISE 501 and CS 504 or equivalent.

CISE 523 Computer Communication and Networks (3): Covers theory of various information and communication networks and operation of open systems that enable exchange of information (data) in an open way to facilitate a range of distributed applications. Topics include – fundamental issues related to reliable transfer of data across serial data link following ISO reference model; data transmission over various types of communication medium; various types of computer networks that provide a switched communication facility over which computers can communicate; and the ISO layered network protocol, network topology, packet switching, routing, networks management, discussion of narrowband and broadband ISDN. Application of

basic traffic theory, switching fundamentals and routing strategies. Prerequisite: EE 321, EE 350 and EE 435 or equivalent.

CISE 524 Management of Information Systems. (3): This course will discuss current methods in use for the design and implementation of modern information technology in organizational systems. It will also provide a comprehensive introduction to basic principles of the legal, economic, and regulatory environment of the information industry. Prerequisite: EE 350, equivalent or ME 502.

7. Ph.D. in CISE Program

The growth in the M.S. in CISE program is a reflection on the systematic approach to develop programs that address future societal manpower needs. Based on the success of the M.S. in CISE program, and the university's desire to expand its doctoral level program offerings, a Ph.D. program in Computer and Information Systems Engineering was developed. This Ph.D. program builds upon the core of the Master of Science in CISE program. The reason for the common core is to provide every student a strong base in systems approach to development of computer-based systems. This is also the uniqueness and strength of this program. We also have Master of Engineering programs and strong research effort in the areas of control systems, signal processing, communication systems and networks, preventive maintenance, computational fluid dynamics, robotics and manufacturing. The Ph. D. program offers three concentrations in the areas of computer communication and networks, control system and signal processing, robotics and computer integrated manufacturing. Further the required and elective courses in each concentration will provide the necessary depth and breadth at advanced level leading to a research-based thesis. The concentrations address the critical technology areas of manufacturing, information and communication, the CFD and SIP and data mining, very high-speed networks and embedded systems. They are closely related and various combinations of these programs will address many of the critical technology areas. The student's advisory committee will help design and define such programs.

The Ph. D. in CISE curriculum requires 51 credit hours of course work and 21 credit hours of research thesis after B.S degree. The course work consists of eighteen (18) credit hours of core courses and eighteen (18) credit hours of concentration, and fifteen (15) credit hours of guided electives. All graduate students must attend graduate seminars for at least two semesters.

Ph. D. in CISE Curriculum

	Major Field Core	Cr.Hr
CISE 501	Data Structures and Algorithms	3
CISE 502	Computer Architecture and Operating Systems	3
CISE 503	Software Systems Design	3
CISE 504	Systems Engineering	3
CISE 522	Computer Aided Systems Design	3
CISE 523	Computer Communications and Networks	3

		Cr.Hr
Computer Communication and Networks Concentration		
CISE 506	Error Correction Codes	3
CISE 524	Management of Information Systems	3
CISE 530	Probability & Statistics, Risk Manag. and Forecasting	3
CISE 600	Database Management Systems	3
CISE 610	Optimization in Operations Research	3
CISE 630	Statistical Information Theory	3
CISE 634	Computer Communication and Networks II	3
CISE 636	Distributed Computing Theory and Design	3
CISE 644	Numerical Visualization	3
CISE 710	System Modeling and Simulation	3
CISE 730	Network Programming	3
CISE 731	Metrics and Models in Software Quality Engr	3
CISE 734	High Performance Computing Applications	3
CISE 735	Network Security and Risk Analysis	3
CISE 737	Optical Communication	3
CISE750a	Special Topics	3
Control and Signal Processing Concentration		
EE 521	Digital Filter Design	3
EE 522	Modern Signal Processing	3
EE 523	Digital Image Processing	3
EE 563	Modern Control Systems	3
CISE 620	Introduction to Computational Intelligence	3
EE 622	Robust Control Theory	3
EE 623	Nonlinear Control Systems	3
EE 625	Digital Spectral Analysis	3
EE 626	Pattern Recognition and Classification	3
EE 720	Statistical Signal Processing	3
EE 721	Adaptive Control Systems	3
EE 722	Intelligent Control Systems	3
EE 723	Adaptive Filtering and Stochastic Control Systems	3
CISE 724	Digital Image Processing	3
CISE750b	Special Topics	3
Robotics and Computer Integrated Manufacturing Concentration		
ME 501	Introduction to Manufacturing	3
ME 504	Vibration	3
ME 513	Flexible Manufacturing Systems	3
ME 544	Intro. to Computational Fluid Dynamics	3
ME 561	Computer Aided Design and Manufacturing	3
ME 562	Design for Manufacturability	3
ME 563	Manufacturing Quality Control and Managem	3
ME 564	Manufacturing Modeling and Simulation	3

ME 565	Predictive and Preventive Maintenance	3
ME 566	Concurrent Engineering in Manufacturing	3
CISE640	Fundamentals of Robotics in Manufacturing	3
ME 643	Manufacturing Diagnosis and Prognosis Tech	3
CISE644	Numerical Visualization	3
ME 645	Transport Phenomena in Manufacturing	3
ME 742	Robotics and Machine Intelligence in Manufact	3
ME 743	Mechatronics Systems	3
CISE750c	Special Topics	3

This Ph.D. degree program will admit students with B.S. degrees in computer science, mechanical engineering, electrical engineering and/or computer engineering and other related engineering program graduates with additional preparation. The courses for the Ph.D. program have been approved and a catalog description is available but not included in this paper.

8. Faculty and Curriculum Development

The new Ph.D. in CISE program has been reviewed by internal and external reviewers and was approved by the Tennessee Higher Education Commission. in January 2000. The program proposal provides six new faculty positions at senior levels in the three areas of concentrations where we need to strengthen our weaknesses. Also sufficient funding has been provided for library resources, electronic access to journals and for facility development. With the addition of new faculty and additional graduate assistantships, we hope to strengthen our existing programs and develop new research efforts to expand our program offering to meet our student program needs and address the critical technology areas of our nation.

9. Conclusion

Systematic development of graduate programs in CISE has been a valuable experience and one that has been very fruitful in addressing the needs of our students. The M.S. in CISE program is quite popular despite the fact that most students have to take an additional one to two semesters equivalent of prerequisite work.

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