Proposal for a B.S. Degree in Computer Systems

Department of Computer Science
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1 Executive Summary

A new degree program in Computer Systems is presented. This program is a spin-off of our highly successful Computer Science degree. Students who graduate with a Computer Systems degree will have a solid foundation in the fundamentals of computer science along with the specialized knowledge necessary to pursue careers in system and network administration, computing environment engineering and information technology management. The goal of the program is to provide students with the theoretical foundation that provides a solid understanding of current day systems, as well as the basis for continued professional development. Computing systems evolve at an exponential rate. Thus, it is critical that if we are to prepare students for the future, we must give them much more than just knowledge of current day systems. We must provide them with core concepts that stand the test of time.

Computer science faculty have had significant experience developing curricula for rapidly changing technology. In addition, approximately one-half of our computer science faculty have had some professional system administration experience varying from a little up to nearly 10 years. We relied heavily on these experiences in the design of this curriculum.

In many ways the curriculum proposed here is unique. Although there are several programs being proposed across the country or in existence that are geared toward giving students system and/or network administration background, most of those programs are primarily focused on what is more appropriately called training. Such degrees prepare students to become system administrators for small sites or very junior system administrators at larger sites. A few computer science departments offer M.S. degrees in system and/or network administration or M.S. degrees in networking. These, like this degree program, are designed to prepare students for careers with greater system responsibilities at a large site with a heterogeneous computing environment.

In the past a general assumption has been that system administrators are trained. This degree program is designed to add specific computing systems knowledge to the foundation courses in the computer science curriculum. Thus undergraduate students should initially

enter system and/or network administration positions with the detailed knowledge to immediately perform in those positions. With sufficient experience, these alums should be able to move into senior positions in system and network design/engineering and/or information technology management

2 Need for Proposed Program

Computing occupations are becoming highly specialized. One of these specializations is system administration/network administration. According to the the U.S. Department of Labor's Occupational Outlook Handbook, 2002-2003 Edition [1] "systems administrators are projected to be among the fastest growing occupations over the 2000-10 period. Job prospects should (be) best for college graduates who are up to date with the latest skills and technologies." Starting salaries for systems administrators in 2001 are reported to have ranged from $50,250 to $70,750.

The Department of Labor's statistics tell only part of the story. Indeed there is a demand for system administrators, but there is also a strong need to be able to evaluate candidates for system/network administrator positions. In an environment in which most system/network administrators learn skills through an apprenticeship-type environment or on their own, it is difficult to know when hiring if the person has the necessary skills and knowledge. A formal college degree program can provide employers with confidence that the prospective employee has an appropriate educational understanding of the necessary concepts. In many ways the field of system administration is currently at a maturity level similar to that of programming in the 1970s. Programming has evolved into software engineering partly through the formalization of the education of programmers through first computer science and now software engineering degrees. A similar maturation is necessary for the field of system/network administration and computing environment engineering. Appropriate education will develop professionals who will become more effective designers of the new computing systems. There will be greater differentiation between designers of systems and those who are maintainers of the systems. This is similar to the differentiation now occuring between designers of software systems and coders.

3 Relevance to University Strategic Plan

We strive to be a national university of choice. This goal requires that we have top quality programs. The program described here will lead to national recognition as not only one of the first undergraduate programs in computer systems, but as a model because of the strong academic foundation provided to students who anticipate a career in the design, planning, engineering, and maintenance of computer systems and computing environments.

4 Related Programs

There are very few degree programs in computer systems with system/network administration in the United States. Some universities offer courses in system administration; some community colleges focus on offering courses aimed at industry certifications. One of the few academic-based programs is a M.S. Degree in Computer and Network System Administration offered by the Department of Computer Science at Florida State University. This program assumes that students have an undergraduate degree in computer science and requires advanced courses in operating systems, computer and network administration and systems programming. There are other programs, such as at Northern Michigan, in which the computer science program offers a network computing degree. This degree includes a programming component as well as the option to take courses such as network programming and Microsoft network certification preparation and Novell certification preparation. Similarly the College of Business at Northern offers a Computer Information Systems degree with a networking track that includes courses aimed at Microsoft or Novell certification. The University of Michigan–Flint's computer science department offers a systems/networking track in their computer science major. This is a traditional computer science major with upper level coursework in systems and networking. Other programs, such as the one being proposed by our School of Technology, focus on "hands-on" system and network administration.

The program proposed here is a spin-off of the B.S. degree program in Computer Science. Our computer science program has prepared numerous students for careers in computing systems over its 28 years of existence. A scan of the computer science alumni list shows alums in many related careers. Job titles include system administrator, network administrator, computer services specialist, network manager, technical support analyst, senior programmer/network analyst, information technologist solutions specialist, systems engineer, systems programmer, computer consultant, systems consultant, internet administrator, DBA/UNIX Administrator, operating systems specialist, and computer systems administrator. Significantly, many job titles also indicate alums who have advanced to higher levels such as senior IS technologist, senior IS&T specialist, manager IT client infrastructure services, consultant enterprise network services, director production systems, manager of advanced technology, deputy chief information officer, vice president of technology, CIS/LAN manager, manager of advanced technology and director of telecommunications. These alums have worked in a wide range of industries including government agencies such as NASA, universities such as Georgia Tech, telecommunications industries such as Ameritech and Sprint and computer/electronics industries such as Motorola and Texas Instruments.

This program has been designed to focus specifically on the needs of students interested in careers in computing systems. The program will share the foundation courses with the existing computer science degree program. Computer systems students will focus their studies through required upper level courses to provide them with a thorough understanding of operating system and network principles. New upper level courses will build on that conceptual foundation to provide students with knowledge of techniques and methodologies for system and network administration. The coursework will conclude with focus on security and performance analysis. These courses in security and performance analysis will also be

available as electives for students in the traditional computer science degree.

5 Program Administration

The program will be housed in the Department of Computer Science. A faculty committee (the Computer Systems Program Committee) will be responsible for the computer systems curriculum. This committee will work through the Department Undergraduate Committee on all curricular issues. Course and curriculum proposals from the Computer Systems Program Committee go to the Undergraduate Committee for recommendations that are then forwarded to the faculty. The Undergraduate Committee is responsible for ensuring that courses common to more than one degree serve all programs effectively. The Undergraduate Committee is also responsible for ensuring an appropriate balance in curricular issues across the different degrees offered by the Department.

The Computer Systems Program Committee is responsible for consulting closely with representatives from industry to ensure that the curriculum stays relevant. In addition, the Computer Systems Program Committee will monitor activities of related professional organizations such as SAGE (The System Administrators Guild) for issues related to the degree program.

6 Faculty Resources

The Department of Computer Science currently has 13 tenured/tenure-track faculty members and 2 Lecturers. Seven of these faculty members have had experience with system administration during their careers, spanning approximately a 25 year time-span. This diversity and longevity of experience provides a solid basis for the development and maintenance of a curriculum that will provide the students an education grounded in principles that will last them a lifetime.

The computer science faculty currently has the expertise to teach all of the new courses. However, adding additional expertise in security would strengthen our course offerings as well as our research and funding potential in this critical area. In addition to the ability to teach the courses for this new degree program, several faculty members have research interests that are closely related to this degree. As examples a recent M.S. student completed work entitled "A Network Visualization Tool: Visual TCP/UDP Animator (VTA)" and a current Ph.D. student is evaluating the effectiveness of various testing techniques to ensure the continuing reliability of systems after modifications

Although we have the expertise to teach the required courses and perform related research, we do not have a sufficient number of faculty to add the necessary number of course offerings to our existing load. One and one-half additional faculty lines will be needed. These can be added over a two-year time frame; the first during the 2003-2004 academic year to allow time to develop the new courses before they are offered during the 2004-2005 academic year. In addition, a graduate teaching assistant will be required to test and set-up the labs.

This support will be needed beginning with the 2003-2004 academic year. Finally, additional administrative support will be needed within the Department to service the increased load due to the multiple degree programs being offered within the Department.

7 Institutional Impact

Students in this curriculum will be taking a similar number of credits in mathematics and general education courses as other computer science students. A few specific courses in BA, EE and MA will be directly affected by increased enrollments.

A primary impact on the institution should be an increase in the number of incoming students and better retention of current students. In addition, the program should draw national attention because of its leadership. Ultimately the quality of the graduates will also attract the attention of industry. Finally, those graduates who chose to remain in the area will provide the campus community with a pool of individuals highly qualified to do system administration and design.

8 Facilities and Equipment

The Department of Computer Science currently has sufficient lab space and computing resources for the existing computer science courses that this degree requires. These resources include four laboratories containing a total of 40 Sun and 40 Linux workstations. In addition, the Department operates several servers primarily for remote access by students.

This new degree program will require two special purpose labs; one for the computer and network administration courses and the other for the performance analysis course. The one lab will consist of clusters of heterogeneous workstations along with a server and associated peripherals. Each cluster can be assigned to a group of students for their computer and network administration labs. A cluster will require a server, several workstations, a programmable switch and associated peripherals. The client workstations for each cluster can be those machines which are being rotated out from the traditional undergraduate labs. The servers and other hardware will likely need to be purchased. Cost per cluster is approximately $4,000. In addition, a networked printer and a top-end wireless network could be shared by the groups. Assuming six clusters, an estimated total cost for the equipment would be approximately $28,500.

The performance analysis lab would require 12 workstations and a server for a cost of approximately $30,000. Assuming that we need to acquire desks and chairs for the students, the total cost of the two labs is estimated at $75,000. The Department does not currently have space for these labs. A large system administration lab is planned for the proposed Center for Integrated Learning and Information Technology (CILIT). This facility is expected to be completed by Fall 2005.

9 Schedule

Because this program is solidly based on the existing computer science program, it can be implemented almost immediately. Five new courses are planned: systems programming, computer administration, network administration, computer and network security and computer and network performance analysis. Systems programming, the first of the new courses taken by students in this curriculum, is a variation of a course that has previously been taught in the Department. Similarly Computer Administration is a modification of an existing course. Hence, minimal additional effort is needed to develop the curriculum through the junior year. The planned schedule is to offer Systems Programming and Computer Administration for the first time during the 2003-2004 academic year. First and second year students next year could transfer into the new program with the first graduates completing Spring 2005. This schedule requires that temporary lab space be found for the necessary lab courses. (Permanent space for the labs should become available when the CILIT is completed in Fall 2005.)

10 Curriculum Overview

The curriculum is based on providing students with a foundation in computing through courses in programming, data structures, computer architecture, operating systems, networks and databases. Given this foundation, students learn principles and current techniques for computer and network administration, security and performance analysis.

The first two years of the computer systems degree overlaps significantly with the first two years of the computer science degree and the proposed software engineering degree. This not only provides economy of scale for the department and the institution, it is of significant benefit to students. Most students come to Michigan Tech with limited awareness of the diverse career opportunities available to them given their interest in computing. Often students would have decided on a career based on whatever opportunities were available to them in high school. If they had a Cisco networking certification course available and they took and enjoyed it, they indicate an interest in networking. If they have had a programming class, they indicate an interest in software engineering and if they have learned programming on their own through their interests in computer games, they express plans to become computer game developers. Given the broadening of their experiences through their undergraduate curriculum, students' interests often change. Thus, the commonality designed into these degree programs provides students with an opportunity to get a solid background in computing while broadening their awareness of career opportunities in the computing field.

Students in all three majors will take CS1000 Computer Science Orientation their first semester. The component of this course that has addressed careers in computing will be significantly enhanced to help students identify their career interests and differentiate more appropriately among the degree opportunities.

Following the common foundation with the computer science degree, students will take

a sequence of courses during their junior and senior years that will give them the specialized knowledge to enter careers in system and network administration and computer environment engineering. These courses will cover computer systems from individual systems through networks. Focus will be on general concepts to provide students with the foundation to work in any current or future system environment. Additional course work will include computer and network security and performance analysis. Courses will have both a classroom and a lab component. The lab components will focus on providing structured exposure to the numerous techniques and systems used in this discipline. In the case of the performance analysis course, which will also be open to students in the traditional computer science degree, the lab component will be separate. Students in the computer systems degree will be required to take the lab; for other students the lab will be optional.

Depending on their interests, students will complement the required courses through their choice of technical electives. These will be chosen from a list of related courses in computer science, mathematics, electrical engineering and business administration. In the future given sufficient demand, additional courses may be added within the Department to broaden the students' exposure to related disciplines. Kernel programming and storage technologies are two possibilities currently under discussion.

Ideally, the educational experience provided through the course work will be supplemented with actual work experience. Because of the uniqueness of this degree program, it is difficult to predict the potential enrollments, however, we are estimating initial enrollments at approximately 100 majors, 25 per year. Thus, we are opting to not require a practicum until we can guarantee that the appropriate environments are available to meet the demand. However, an experiential component will be strongly encouraged. Initially, this will be encouraged via several channels. Students, as early as their sophomore year, will be encouraged to find lab consulting positions in appropriate undergraduate labs on campus. This will provide students with an opportunity to develop both their technical and communication skills by interacting with users. It should also help them determine their interest in a career that generally requires significant user interaction. More advanced students may gain actual experience in a system administration environment through a co-op or on campus. We will work to identify appropriate co-op positions through the many corporations that currently hire our graduates. We will also identify appropriate environments for students to get "structured" experience on campus. Initially we will work with the Center for Experimental Computation which provides system administration for the 450 machines and 3000 users in Fisher Hall to identify appropriate apprenticeship opportunities for computer systems students. In addition to its proximity, an added advantage of the Center for Experimental Computation is the educational background of the staff members. One current staff member has a M.S. degree in Computer Science and we are in the process of recruiting a new director and senior system administrator who is also expected to have a M.S. in Computer Science.

11 Conclusion

Projections of future employment opportunities indicate that careers related to computing are among the fastest growing career occupations. Similarly, it is clear that the applications of information technology are going to increase in the future. In order for Michigan businesses and industry to remain competitive, it is critical that there be professionals available who are capable of planning, designing, managing and maintaining suitable computer systems to solve the problems of business and industry. This degree program aims to provide those professionals.

12 Detailed Curriculum

12.1 Requirements

Computer Science Core			**26**
CS 1000	Orientation	1	
CS 1121, 1122, 2321 (or CS1131 and CS1132)	Computer Science I, II, Data Structures	9	
CS 2141	C++ as a Second Language	3	
CS 2311	Discrete Structures	3	
CS 3421	Computer Architecture	4	
CS 4321	Algorithms	3	
CS 4411	Intro to Operating Systems	4	
CS 4421	Database Systems	3	
CS 4461	Networks	3	
CS 3XXX	Systems Programming	3	
CS 3XXX	Computer Administration	4	
CS 4XXX	Network Administration	4	
CS 4XXX	Computer and Network Security	3	
CS 4XXX	Computer and Network Performance Analysis	3	
CS 4XXX	Computer and Network Performance Analysis Lab	1	
Additional Requirements			**14**
BA 3200 or BA 3610	IS/IT Management or Operations Management	3	
EE 3010	Circuits and Instrumentation (for non-majors)	3	
Technical Electives (selected courses in BA, CS, EE, MA)		8	
Math Courses			**17**
MA 1090	Functions, Change and Chance	3	
MA 1160	Calculus with Technology	4	
MA 2330	Honors Linear Algebra	3	
MA 2720	Statistical Methods	4	
MA 3203	Intro to Cryptography	3	
Gen Ed Requirements			**36**
UN 1001	Perspectives on Inquiry	3	
UN 1002	World Cultures	4	
UN 2001	Revisions	3	
UN 2002	Institutions	3	
Distribution Courses	(including HU 3120 Technical Communications)	15	
Lab Science		8	
Electives			**7**
TOTAL			**124**

12.2 Four Year Schedule

Fall			Spring		
		Year 1			
CS 1000	Orientation	1	MA 1160	Calculus with Technology I	4
MA 1090	Functions, Change, and Chance	3	CS 1122	Intro to Computer Science II	3
CS 1121	Intro to Computer Science 1	3	UN 1002	World Cultures	4
UN 1001	Perspectives on Inquiry	3		Science Elective	4
	Science Elective	4			
	Co-curricular Activities			Co-curricular Activities	
		14			15
		Year 2			
MA 2330	Linear Algebra	3	MA 2720	Statistical Methods	4
CS 2311	Discrete Structures	3	CS 2141	C++	3
CS 2321	Data Structures	3	CS 3421	Computer Architecture	4
UN 2001	Revisions	3	UN 2002	Institutions	3
	Distribution Elective	3		Distribution Elective	3
	Co-curricular Activities				
		15			17
		Year 3			
CS 3XXX	Systems Programming	3	CS 3XXX	Computer Administration	4
CS 4411	Intro to Operating Systems	4	CS 4461	Computer Networks	3
CS 4321	Intro to Algorithms	3	MA 3203	Intro to Cryptography	3
	BA Selection	3	EE 3010	Circuits and Instrumentation	3
	Distribution Elective	3		Distribution Elective	3
		16			16
		Year 4			
CS 4XXX	Network Administration	4	CS 4XXX	Performance Analysis	3
CS 4XXX	Computer Security	3	CS 4XXX	Performance Analysis Lab	1
HU 3120	Tech. and Scientific Comm.	3	CS 4421	Database Systems	3
	Technical Elective	3		Technical Elective	3
	Free Electives	4		Free Elective	3
		17			13

12.3 New Course Descriptions

CS 3XXX Systems Programming Development of programs on modern operating systems. Topics include: scripting; compilation, linking, loading; libraries; process creation; file system access and protection; network programming; heterogeneity. Prerequisites: CS 2141, CS 3421.

CS 3XXX Computer Administration Administration of non-networked computers. Topics include: operating system installation; boot-up and shutdown; process management; account management; file systems; storage technology; backups; serial devices. Prerequisite: Systems programming.

CS 4XXX - Network Administration Administration of computer networks. Topics include: TCP/IP networking; mail; printing; configuring and building kernels; remote filesystems; license management; managing web systems; common network administrative services. Prerequisites: CS4461, Computer administration.

CS 4XXX - Computer and Network Security Development of administration of secure software systems. Topics include: principles of software development, practical cryptography, program security, operating system security, network security, database security, administration, legal and ethical issues. Prerequisites: MA 3203, CS4461.

CS 4XXX - Computer and Network Performance Analysis Analysis of the performance of computer systems. Topics include: measurement techniques and tools, probability theory and statistics, experiment design and analysis, simulation, queuing models. Prerequisite: MA 2720.

CS 4XXX - Computer and Network Performance Analysis Laboratory Application of analysis techniques.

12.4 Course Descriptions for Existing Courses Included in Degree

CS 1000 Computer Science Orientation Introduction to computer science as a major field of study. Topics include CS options and subfields, career opportunities, the role of computers in society. Students are acquainted, through actual use, with University computing facilities. Restricted to CS Majors only.

CS 1121 Introduction to Computer Science I Starting point of the computer science program. A high-level, object-oriented programming language is introduced as a problem-solving tool. Topics include design, coding, documentation, debugging and testing of programs. Programming assignments are given in both a closed lab setting and as homework. Prerequisite: MA 1032.

CS 1122 Introduction to Computer Science II Continuation of CS1121. Topics include data abstraction, class hierarchies and polymorphism, list, stack and queue data structures, informal complexity-based algorithm and data structure choices, recursion, and an introduction to software

development methods. Homework programming assignments are given, including a medium-scale project. Prerequisite: CS 1121.

CS 2141 C++ as a Second Language This course provides an accelerated introduction to C++ (and C) and an introduction to object oriented design using UML. Topics include C, C++, pointers, virtual functions, use of libraries, object oriented design with UML, structured testing and verification, and object oriented programming in C++. Homework programming assignments are given. Prerequisites: CS 1132 or CS 2321

CS 2311 Discrete Structures Presents fundamental concepts in discrete structures that are used in computer science. Topics include sets, trees, graphics, functions, recursion, proof techniques, logic, combinatorics, formal languages, and machine models. Prerequisites: CS 1122 Minimum Grade: D or CS 1132 Minimum Grade: D.

CS 2321 Data Structures Presents fundamental concepts in data structures. Topics include ADTs (trees, priority queues, dictionaries and graphs) and their implementations, algorithm analysis, sorting and text processing. Programming projects are designed to apply these topics. concepts. Prerequisite: CS 1122

CS 3421 Computer Architecture Introduction to the logical structure of computers, including the fundamentals of logic design, information storage and manipulation, control, input/output, and assembly language programming. Topics include a review of current hardware technology, combinational and sequential logic, arithmetic, datapaths, hard-wired control, interrupts, caches, virtual memory, and an introduction to pipelining. Prerequisites: CS 2311.

CS 4321 Introduction to Algorithms Fundamental topics in algorithm design, analysis, and implementation. Analysis fundamentals include asymptotic notation, analysis of control structures, solving recurrences, and amortized analysis. Design and implementation topics include sorting, searching, and graph algorithms. Design paradigms include greedy algorithms, divide-and-conquer algorithms, and dynamic programming. Prerequisite: CS 2311 and (CS 1132 or CS 2321).

CS 4411 Introduction to Operating Systems This course presents topics on program representation and execution; operating systems; process and threads; process scheduling; memory management; file systems; network programming; and security and privacy. Prerequisites: CS 2322 and CS 3421.

CS 4421 Database Systems Topics include goals of database management; data definition; data models; data normalization; data retrieval and manipulation; security, integrity, and privacy measures; file, data, and storage organization; object-database systems; and, parallel and distributed databases. Surveys a number of general database systems, and examines in detail at least one database system. Prerequisites: CS 2141 and CS 4411.

CS 4461 Computer Networks Computer network architectures and protocols: design and implementation of datalink, network, and transport layer functions. Introduction to the Internet protocol suite and to network tools and programming. Prerequisites: CS 4321 and CS 4441.

BA 3200 IS/IT Management Focuses on the theory and application of the information-systems discipline to organizations and roles of management, users, and information systems professionals. Covers the role of telecommunications and distributed systems for business, the use of information and its implications for decision support in organizations, and the ethical, legal, and social issues of IT. Prerequisites: BA 2310 and (BA 1200 or CS 1122 or CS 1132).

BA 3610 Operations Management Focuses on the principles of operations management for both manufacturing and service industries. These include strategy, forecasting, design, quality, processes, capacity, planning, location, layout, human, supply chain, inventory, JIT, MRP, scheduling, project, and maintenance management. Emphases the integration of all these decisions with the rest of management. Prerequisites: BA 2100 or MA 2710 or MA 3710.

HU 3120 Technical and Scientific Communication A study of written and oral communication in technical and scientific environments; emphasizes audience, writing processes, genres of scientific and technical discourse, visual communication, collaboration, professional responsibility, clear and correct expression. Students write and revise several documents and give oral report(s). Restrictions: Must be enrolled in one of the following Class(es): Junior Senior. Prerequisites: UN 1002 or UN 1003 or UN 2002.

EE 3010 Circuits and Instrumentation Designed for nonmajors. Covers the principles of electrical and electronic measurements, including dc, ac, semiconductor devices, amplifiers, and filtering. Restrictions: May not be enrolled in one of the following Major(s): Electrical Engineering.

MA 1090 Functions, Change, and Chance A survey of mathematical ideas and reasoning for computer science majors. Topics may include difference equations and recursion, proof by induction, random number generators and elementary number theory, game trees and strategy, probability, and simulation. Restrictions: Must be enrolled in one of the following Major(s): Computer Science.

MA 1160 Calculus with Technology I An introduction to single-variable calculus, which includes a computer laboratory. Topics include trigonometric, exponential, and logarithmic functions, differentiation and its uses, and basic integration. Integrates symbolic tools, graphical concepts, data and numerical calculations. Prerequisites: MA 1032 or MA 1033.

MA 2330 Honors Elementary Linear Algebra Introduction to linear algebra and how it can be used, including basic mathematical proofs. Topics include systems of equations, vectors, matrices, orthogonality, subspaces, and the eigenvalue problem. Not open to students with credit in MA 2320. Prerequisites: MA 1150 or MA 1160.

MA 2720 Statistical Methods Introduction to the design and analysis of statistical studies. Topics include methods of data collection, descriptive and graphical methods, probability, statistical inference on means, regression and correlation, and single variable ANOVA. Not open to students with credit in MA3710. Restrictions: May not be enrolled in one of the following Major(s): Mathematics Prerequisites: MA 1032 or MA 1033.

MA 3203 Introduction to Cryptography Topics include private-key cryptography, shift substitution, permutation and stream ciphers, cryptanalysis, perfect secrecy, public-key cryptography, and the RSA cryptosystem. Prerequisites: MA 2320 or MA 2330 or permission of instructor.

UN 1001 Perspectives on Inquiry Engages students in college level inquiry through which they develop fundamental intellectual habits, understand how to integrate perspectives on knowledge, and begin to learn how to meet the changing needs of a global, technological, diverse, and environmentally sensitive society. Restrictions: Must be enrolled in one of the following Class(es): Freshman.

UN 1002 World Cultures Examines diversity and change around the globe from perspectives of social sciences, humanities, and arts; explores human experience from prehistory to present. Classroom lectures accompanied by films, live performances, and guest speakers. One complete year of a single foreign language plus World Cultures (UN1003, 1-credit-activities) substitutes for World Cultures. Restrictions: Must be enrolled in one of the following Class(es): Freshman.

UN 2001 Revisions Provides direct instruction in communication and strategies for revision. Writing portfolios provide a starting point for the course. Instruction in the composing process is often accompanied by work in small groups and conferences with the instructor. Restrictions: Must be enrolled in one of the following Class(es): Sophomore. Prerequisites: UN 1001 and (UN 1002 or UN 1003)

UN 2002 Institutions From families to governments, to markets, to our interactions with the natural environment, institutions organize collective human action. Introduces students to the nature and role of institutions in shaping today's world. Specific topics will vary by section, but all sections address a set of core questions and concepts. Restrictions: May not be enrolled in one of the following Class(es): Junior Senior.

12.5 Course Descriptions for Sample Technical Electives

CS 4431 Advanced Computer Architecture Architecture of high-performance parallel computer systems. Introduces various forms of parallelism, such as multiple functional units, pipelining, multiprocessors, and processor arrays. Interleaved memory, caching, and interconnection networks are also covered. Includes analytic and simulation models of architectural features that implement or support parallel processing. Prerequisites: (CS3421 and CS4411) or (EE2170 and EE3170 and CS4411).

CS 5431 Advanced Computer Architecture An in-depth study of various aspects of parallel processing, with an emphasis on parallel architectures. The course will have an analytical focus and will investigate models of various aspects of the design and analysis of parallel systems. Topics include simple uniprocessor/multiprocessor performance models, pipelining, instruction-level parallelism and multiprocessor design issues. Prerequisites: CS4431.

CS 4441 Operating Systems Continuation of CS4411. Topics include file systems, I/O, distributed systems, security, and symmetric multiprocessing. A significant programming project is required. Prerequisites: CS3141 and CS4411.

CS 5441 Distributed Systems Time and order in distributed systems. Mutual exclusion, agreement, elections, atomic transactions. Distributed File Systems. Distributed Shared Memory. Distributed System Security. Issues in programming distributed systems. Selected case studies. Prerequisites: CS4441 and CS4431.

EE 3173 Hardware/Software System Integration Covers the integration of hardware and software into a complete working system. Includes design and construction of I?O devices for microprocessor – or microcontroller-based systems, communication and bus protocols, programming in assembler language and in "C", system integration and testing. Also covers the use and integration of FPGAs using both schematic capture and HDL design tools. Laboratory assignments include signal-processing applications. Prerequisites: EE 2150 and (EE2170 or EE 2171) and EE 3130 and CS 2141 and CS3421.

EE 3175 Modeling and Simulation of Computer Systems Covers the theory and practice of using computer-aided modeling and simulation as tools for digital system design. Topics are drawn from both discrete event simulation and stochastic modeling of system performance and reliability, including Monte Carlo approaches, queuing models, and Markov models. Includes system modeling laboratory assignments. Prerequisites: CS 2911 and CS 2141 and CS 3421 and (MA 3710 or MA 3720) and (EE 2170 or EE 2171).

EE 4255 Wireless Communications Wireless communications. Principles of wireless communication systems. Applications include cell phones, computer networks, paging systems, satellite communications, radio, television and telemetry. Prerequisites: EE 3150.

MA 3202 Introduction to Coding Theory Transmission via noisy channels, Hamming distance, Linear Codes, the ISBN-code, encoding and decoding, finite fields, Reed-Solomon codes, deep space communication, the compact disk code, sphere packing bound, Hamming Codes, Hamming Decoding. Prerequisites: MA2320 or MA2330

MA 3210 Intro to Combinatorics Topics to include set theory, mathematical induction, integers, functions and relations, counting methods, recurrence relations, generating functions, permutations, combinations, principle of inclusion and exclusion, graphs (including planar graphs). Further possible topics: graph coloring, trees and cut-sets, combinatorial designs, Boolean algebra. Prerequisites: MA2320 or MA2330.

MA 4209 Combinatorics and Graph Theory An introductory course in combinatorics and graph theory. Topics include designs, enumeration, extremal set theory, finite geometry, graph coloring, inclusion-exclusion, network algorithms, permutations and trees. Prerequisites: MA3210.

MA 4211 Inform Theory/Data Compression An introduction to information theory and data compression. Topics include information and entropy, channel and channel capacity, Kraft-McMillan inequality, maximum likelihood decoding, reliability, Shannon's Theorem, lossless data compression, arithmetic coding, higher order modeling, adaptive methods, dictionary methods, transform methods and image compression. Prerequisites: MA3210.

UN 3002 Cooperative Laboratory Offered by each participating college or school - the free elective option of cooperative education. Requires 2.20 GPA or better, registration with the Office of Cooperative Education, acceptability by a recognized employer. In addition transfer students must have completed at least one full-time semester on the MTU campus. Restriction: Sophomore, Junior, Senior standing only; Dept. Perm. Reqd.

UN 3003 Cooperative Lab Technical Elective Offered by each participating college or school-the technical elective option of cooperative education. Require GPA 2.20 or better, registration with the Office of Cooperative Education, acceptability by a recognized employer. In addition, transfer students must have completed at least one full-time semester on the MTU campus.

13 References

1. U.S. Department of Labor, "Occupational Outlook Handbook", 2002-2003 Edition, http://www.bls.gov/oco/home.htm.