PROPOSAL 7-01

PHD PROGRAM IN COMPUTER SCIENCE

The Senate approves the program as described below.

Spurred by a national investment in network infrastructure and research in associated areas, use of information technology has expanded dramatically. This has increased the number of students pursuing undergraduate degrees in related fields, and has warranted sustained national investment in research in this area.

The Department of Computer Science at Michigan Technological University can significantly increase its contribution in this arena. We have, over the past few years, focused on increasing our research productivity, while maintaining a strong undergraduate program. Through addition of a PhD program, we can continue to increase our research contributions while satisfying a national need for highly trained individuals in computer science.

1. Need and Motivation for the CS Program

Department Overview The Department of Computer Science currently has twelve tenure-track or tenured faculty. The department offers the Bachelor of Science and Master of Science degrees in Computer Science. Additionally, the department is a participant in the Computational Science and Engineering (CS&E) PhD program.

Current undergraduate enrollment stands at approximately four-hundred. Current enrollment in the MS program is approximately forty. Growth in these programs over the past several years has followed national trends.

The CS&E program fosters interdisciplinary research with other science and engineering departments. This program currently has an enrollment of twelve. Of these twelve students, the dissertation advisors of seven students are on the faculty in the Department of Computer Science.

Computing facilities in the Department include a network of over 100 Sun Sparc, Digital Alpha, SGI and Linux servers and workstations. Research equipment available to Department faculty includes a 128-node Beowulf cluster, a 12-node Sun E4500, and Internet 2 access.

Need for a PhD Program The 1998-1999 Taulbee Survey(1) indicates that PhD production since 1996 has been virtually flat. Unemployment among 1999 PhD program graduates was essentially zero (about one percent). Meanwhile, the survey indicates that PhD granting Computer Science departments expect the size of their faculty to increase by seven percent over the next two years. As an example of the demand for computer science PhDs, the December 1999 issue of the Communications of the ACM contains 62 pages of advertisements for faculty positions in computer science. (Note that each page has four or five advertisements with many of the ads being for multiple positions.). This shortage of qualified computer scientists will certainly adversely affect the small colleges and universities in the State of Michigan, and the information technology business sector who will all be competing for the same small supply of qualified computer scientists with a PhD Further, proposed information technology research and development funding, across governmental agencies, for fiscal year 2001 is 35 greater than estimates for fiscal year 2000. Even though the University of Michigan, Michigan State University, Wayne State

University and Western Michigan University have PhD programs in computer science, the data presented above clearly shows there is a state and national need for significantly more PhDs in computer science.

The department has made a concerted effort to increase its research contributions, while maintaining a strong undergraduate program. We have, with University support, initiated this transition through the addition of faculty positions at a rate sufficient to permit greater emphasis on research by both existing, and incoming, faculty. Over the past four years, six tenure-track faculty and two lecturers have been added. This reflects a net increase of five in the tenure-track faculty. The department has been successful in hiring research active faculty into these positions. Further, the department has recently been joined by a faculty member with only research duties, who is affiliated with NASA Goddard.

This investment has created productive research programs in several areas. Research funding awarded to the department has increased by nearly an order of magnitude over the past four years, as summarized in Table 1 funding-awarded.

Calendar Year	Funding Awarded
1996	$105,000
1997	$301,000
1998	$833,000
1999	$2,005,000
2000 (to-date)	$710,000

Table 1: External Funding Awarded

In addition, several pending grants are currently under consideration. This funding has been from both industrial and governmental sources. Appendix B provides more detail on the funded grant activity of the CS department in the last 4 years.

In addition to increasing our external funding, the number of publications from the computer science faculty have also doubled as summarized in Table 2 publications.

Calendar Year	Publication Count
1996	12
1997	14
1998	23
1999	25

Table 2: Number of Publications reported in the Faculty Publication Booklet

Sustainment of our current research productivity, as well as continued growth, is closely tied to our ability to attract doctoral students. To date, research assistantship positions have been filled with outstanding MS students, and with PhD students enrolled in the CS&E program. However, the scope of our research is now extending beyond the boundaries of an interdisciplinary program. Additionally, the depth and duration of our research projects are beginning to exceed the abilities of MS students.

Development of a PhD program in computer science will allow us to draw from the larger pool of candidates interested in research in traditional fields of computer science. The program will enable us to

sustain growth in our computer science research contributions and help to address a national need for highly trained computer scientists.

2. Program Description

Admission Requirements While this document outlines the rules and procedures to be used in the CS PhD program, it should be noted that all of these rules and procedures are, by default, subject to current rules of the Graduate College and, if there is a conflict, the Graduate College rules have precedence. Students with a BS or MS in computer science or a related field are encouraged to apply for the CS PhD program.

Advisory Committee Each student will have an Advisor who is a member of both the MTU graduate faculty and the Computer Science tenure-track faculty. The Advisor will have the primary responsibility for supervising the student's research project and for directing the student's academic and professional development. (Before the Advisor is appointed the student will be advised by the CS graduate director.)

Each student will have an Advisory Committee consisting of the student's Advisor and at least three additional members. Two of the three may be from Computer Science. At least one committee member must be from outside the CS department. All Advisory Committee members from MTU must be members of MTU's Graduate Faculty. The Advisory Committee members will be selected by the Advisor in consultation with the student.

Comprehensive Examination Each student must pass the Comprehensive Examination. This examination is given in two parts: a Qualifying exam and a Specialty exam. The Qualifying exam must be taken first. After the Qualifying exam has been passed, a student may take the Specialty exam. The tests will be given (when requested) in the fall and spring semesters of each year. Each exam will be both written and graded by at least two graduate faculty chosen by the CS department graduate director. The CS department graduate director and the faculty who wrote the exam will form a committee to determine pass or failure for each exam.

Qualifying The Qualifying Exam will consist of three separate exams. One will cover Theory (Mathematical Foundations, Computing Theory, and Analysis of Algorithms) and two others will cover areas chosen by the student. The intent of the Qualifying exam is to ensure adequate knowledge both of the theory needed in all fields of Computer Science and of two different general research areas (such as AI, graphics, software engineering, compilers, operating systems, etc.) within computer science. The Qualifying exams will be 4-hour written exams for which the faculty responsible for the exam will provide a reading list. The exam may be retaken once only with the approval of the CS department graduate director and three members of the student's Advisory Committee. (Note: It is possible that student won't have chosen an advisory committee at the time of taking the qualifying exams. In that case, the department graduate committee will act as the student's committee.) A student need only retake those part(s) of the Qualifying exam that were not passed on the first attempt.

Specialty The Specialty Examination is an in-depth examination in the area of research that the student plans to pursue. The student's Advisory Committee will conduct the exam. To allow the student to prepare for the specialty exam, the advisory committee will provide a reading list of appropriate material. The student passes the Specialty Examination if 75% of the Advisory Committee votes pass. The exam may be retaken once only with the approval of the CS department graduate director and three members of the student's Advisory Committee.

Coursework Requirements Each student must have demonstrated appropriate breadth of knowledge in computer science. This may be demonstrated by having completed an approved MS program in computer science or satisfying current course work requirements in the MS program in computer science at MTU. The courses available for meeting this breadth requirement are already taught as part of the MS degree. For reference they are listed in Appendix C (on reserve in the J. R. Van Pelt Library). The coursework necessary for depth in a student's research area will be determined by the student's Advisory Committee.

New courses, some of which have already been taught as seminar courses, will continue to be taught on demand and will be added to the curriculum when sufficient demand warrants. These courses are listed in Appendix D (on reserve in the J. R. Van Pelt Library).

Teaching Portfolio Since one major objective of this PhD program is to prepare students for academic careers, provisions will be made to assist students in preparation for careers in academia. Thus, students in the Computer Science PhD program will be encouraged (but not required) to prepare a teaching portfolio during their studies. To complete a teaching portfolio a student would be expected to teach at a level and in a subject area selected by mutual agreement with the Department Chair and the student's Advisor. Prior to the student's teaching assignment, the student, Advisor and Department Chair will determine what training the student should receive in preparation for his/her instructional duties. In addition to teaching experience, a student should prepare a portfolio of written materials which would include at a minimum: a personal teaching philosophy statement and course materials generated while teaching.

Dissertation Proposal This is a written and oral description of the research plan made by the student to his/her Advisory Committee. The student's advisory committee must unanimously agree that the research plan is acceptable. The department graduate director will be notified of the outcome of the Dissertation Proposal. The oral proposal is open to the University community.

Research Review At least three months prior to the dissertation defense, the student will present his/her research findings to his/her Advisory Committee for its approval. While the presentation will be oral, a written outline of significant results should be provided for committee members. The purpose of this review is to evaluate the contribution of the work as well as to assist in maintaining a focus for the dissertation.

The student's Advisory Committee must agree that the research is acceptable and that the student's progress is satisfactory. The student will be allowed to repeat the research review until such approval is given.

Dissertation Defense The research conducted by the student will be presented to the Advisory Committee as a written dissertation. An oral presentation of that dissertation will be made following the completion of the written work. The oral defense is open to the University community. In keeping with MTU graduate school policy, 75% of the advisory committee must vote to accept the dissertation for the student to pass.

3. Impact on Existing Programs

The proposed new Computer Science PhD program will have a substantial impact on the future enrollment in the existing non-departmental Computational Science and Engineering (CS&E) PhD program. The CS&E program was created six years ago and has served the dual roles of providing a computationally centered interdisciplinary PhD program for research in the sciences and engineering and a vehicle for more narrowly focused research in the field of computer science. This second role has been provided precisely because there is no Computer Science PhD program available.

The CS&E PhD program has a current enrollment of twelve active students, seven of whom are advised by Computer Science Department faculty members. These latter students are doing research primarily in the field of computer science. They are expected to remain in the CS&E PhD program but new students with similar interests are likely to choose the CS PhD program. The availability of a Computer Science PhD program is likely to attract more PhD students than the CS&E program alone because new students who desire a traditional computer science PhD will prefer the new program to an interdisciplinary program such as CS&E. Although the proposed CS PhD will diminish the enrollment in the CS&E PhD program in the future, the two programs together will have more students than the CS&E program would have alone.

It is expected that there will be much cross-over of students between CS and CS&E courses. Courses in the new CS PhD program will be cross-listed as CS&E courses at the instructor's discretion. In addition, certain Computer Science Department faculty have research interests most accurately described as computational science and engineering, rather than computer science per se. Such faculty are likely to recruit and advise CS&E PhD students rather than CS PhD students.

Adding the CS PhD program will likely impact the other degree programs within the Computer Science Department. If resources are not stretched too thin, this impact should be primarily positive. In particular, a PhD program will help us to attract and retain the highest quality faculty. This clearly will be a positive impact for the MS and BS programs. In addition, the increase in research activity associated with the PhD program will provide more opportunities for undergraduate and Master's students to participate in research and will facilitate the Department in maintaining currency of the undergraduate and graduate courses and curricula. Finally, the increased course offerings resulting from having a PhD program will provide opportunities for greater depth and breadth for MS students.

4. Program Goals and Assessment

Many aspects of this section are closely related to the university mission and vision statements. The need for technological competence as a student learning outcome is addressed in both the Mission and Vision Statements. The skills acquisition that gives the graduate the ability to adjust in dynamic environments is in the MTU Mission Statement. The need to be a good communicator is also mentioned in the MTU Vision Statement.

Background Preparing students to be technological leaders is the main thrust of our graduate programs. To help our students become better communicators graduate students are required to prepare dissertation proposals and give oral presentations. The PhD dissertation is expected to address some current research issue(s) in some field of computer science. One heuristic in choosing a dissertation topic is that a dissertation focuses on extending the boundaries of computer science theory and/or practice to the extent that publications will result from the dissertation work.

Departmental Goals for Student Learning Outcomes The Department goals for students in the PhD program include:

Technological Competence Students will be well prepared for professional employment in the field,

Continuous Improvement Students will be prepared to continuously improve their professional skills and remain up-to-date in their field, and

Communication Students will have the ability to communicate effectively with users as well as peers (computing professionals) about computing issues.

The Department believes if a student satisfies the three goals (or learning outcomes) mentioned above, that student will be prepared to become a successful computer scientist.

Learning Outcomes and Their Measures The following measures will be used to determine how well our students are satisfying our goals and objectives. Multiple measures for each learning outcome are being planned.

Learning Outcome I: Technological Competence Upon completion of the graduate degree, the student will be well prepared for a professional position in computer science.

Each PhD student must prepare written proposals, prepare a dissertation, and give oral presentations on their research topic. The collection of documents becomes a portfolio of examples that may be used to assess the technological competence of the graduate student. The oral presentations may also be used to measure learning outcomes.

After the student's defense (e.g., the final oral presentation) the student's examining committee will assess the student's technological competence. Using standardized forms developed by the Graduate Committee, the examining committee will assess the student's knowledge acquired from graduate courses; the student's specialized knowledge acquired from graduate research; and the student's longitudinal development.

After the examining committee has completed the assessment of the student, the Departmental secretary will remove student identification and keep the forms until their eventual collation and evaluation by an assessment committee appointed by the Graduate Committee.

Learning Outcome II: Continuous Improvement The ability of a student to be able to continuously improve their professional skills and remain up-to- date in their field is vitally important.

After the student's defense (e.g., the final oral presentation) the student's examining committee will assess the student's ability to apply research skill. Using standardized forms developed by the Graduate Committee, the examining committee will assess the student's ability to use problem solving skills developed and taught in graduate courses and the student's specialized research skills acquired from graduate research.

After the examining committee has completed the assessment of the student, the Departmental secretary will remove student identification and keep the forms until their eventual collation and evaluation by an assessment committee appointed by the Graduate Committee.

Learning Outcome III: Communication The ability to be able to communicate effectively with users as well as peers (computing professionals) about computing issues is critical.

Each PhD student must prepare written proposals, dissertation, or project report, and give two oral presentations on their research topic. The collection of documents becomes a portfolio of examples that may be used to assess the communication and technical writing skills of the graduate student. The oral presentations also are used to determine the graduate student's ability to communicate technical matters.

Time Line and Program Administration The Department's Graduate Committee will provide and ensure the administration of the PhD assessment plan. This committee will develop strategies to collect, analyze, store and report assessment data. Further, this committee will prepare a summary of the results to be reviewed by the faculty and students. The major professor of each graduate student will use assessment forms during each "portfolio" event: dissertation proposal; final oral presentation; and, finally "reading" a dissertation. The assessment forms will be given to each advisor prior to the ``portfolio" event.

Faculty Involvement: The faculty as a whole will review the measurement tools before they are used. In addition, each year the faculty will review the measurements at least in summary form. During these reviews the faculty will be able to suggest changes to the goals (learning outcomes), measures, and information to be collected for a measure.

Student Involvement: Each year the students will receive the summaries, and they will be invited to attend a session with the Graduate Committee during which questions about the assessment reports are answered. Also during these meetings the students will be able to suggest changes in the assessment process.

Improvements Based on Assessment Measurements: Each year after the assessment results are in, they will be reviewed by the Graduate Committee, and a summary of the results will be prepared for the faculty and students. When the results are reviewed with the faculty and the students, these groups will also be asked for suggested improvements to our curriculum based on the results.

The Graduate Committee will review all the suggested improvements, and then the Committee will meet with the parties who could help implement these improvements. The parties who could help implement the improvements, the Graduate Committee, and the Department Chair will discuss the pros and cons of trying to make the suggested improvements. As a group, these persons will decide which suggested improvements should be implemented; this group may also discuss how the implementations should be done.

During the following year, when the Graduate Committee prepares its annual assessment summary, it will include in this summary the suggestions from the following year and what was done based on these suggestions.

Cost Effectiveness: None of the requested activities is particularly fiscally expensive. The information to be measured is already available. An important concern is finding time for members of the Graduate Committee and any assessment committee.

Evaluating the Assessment Process Itself: Each year when the Graduate Committee prepares its annual summary and when this summary is discussed with the faculty and students, the question of the assessment process itself will be discussed. Suggestions will be requested for changing and improving the process. In the following annual report, actions taken on the previous year's suggestions for process improvements will be reported on.

Equity and Diversity The Department has considered our goals, learning outcomes, and measures, and does not believe that any group or groups will be adversely affected by our plans or planned activities.

5. Resource Issues

The Computer Science Department is undergoing a significant growth period, due largely to the increase in undergraduate majors from roughly 230 in 1996 to over 400 in 2000. It seems reasonable to expect that this growth will continue for some time. Due to this growth, several faculty positions have been added recently and more are needed. As a consequence of this growth period we now have a critical mass of faculty and diverse research interests that make a PhD in CS not only possible, but necessary in order to attract the kind of faculty that we need to support both our undergraduate and graduate missions.

Thus, it appears that no additional resources are necessary to begin a CS PhD; the faculty and the equipment are already here. It is anticipated that external funding will suffice to support the additional CS graduate students that the program will attract. The CS department is already handling the course load necessary to implement the PhD program contained in this proposal. No additional courses must be taught. However, the CS department anticipates an increase in the number of faculty positions to meet increased undergraduate enrollments and increased class offering to support the BS in Computer Engineering. This increase in faculty will also expand the diversity and depth of graduate course offerings as new faculty will definitely contribute to the PhD program.

The J.R. Van Pelt Library currently holds subscriptions to the full journal publications and most major conference proceedings of the major computer associations: IEEE, ACM and SIAM. This, along with interlibrary loan, provides an adequate base to support PhD level research. Additional journals to support specific research areas would strengthen the program.

One area in which we do not have enough resources, however, is space. The CS department is currently ``distributed'' into multiple buildings and severely limited in space. These space needs exist irrespective of the CS PhD program.

1. Mary Jane Irwin and Frank Friedman, "PhD Enrollment Levels Off; MS and Undergrad Continue to Rise", Computing Research News, Volume 12, Number 2, March 2000.

Adopted by Senate: December 13, 2000
Approved by President: December 15, 2000