A First Step in Strategic Visioning for
Computing and Information at Michigan State University

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Document Overview

This whitepaper proposes an immediate first step in realizing an ambitious vision for Michigan State University to capitalize on the transformational nature of computer science. The proposed actions are motivated by discipline-based needs and opportunities in Computer Science and the Natural Sciences. We briefly motivate and outline the vision. We then propose a natural first step toward this vision and provide the rationale behind performing this step now.

The Transformational Nature of Computer Science

Computer science began as an established discipline in the early 1960's. During its developmental stages, it focused inward on the challenges of building hardware and software and on understanding the theoretical and practical limitations of computing. Early research focused on core areas such as algorithms, data structures, operating systems, and compilers. Computers and computing significantly improved existing processes, but were relatively expensive and not sufficiently accessible to affect underlying paradigms.

However, the last several decades brought about a series of technological breakthroughs with profound effects. Today, computing devices are small, fast, inexpensive, and interconnected to provide nearly ubiquitous access to digital information and computational power. With computers now integrated into virtually all aspects of our lives, we are seeing fundamental shifts in existing paradigms as well as the emergence of entirely new ones. Research areas once considered core have become spring boards for new interdisciplinary research and are producing leapfrog advances in emerging fields.

Like the discipline, computer science at MSU is turning its focus outwards. Founded in 1968 as a department within the College of Engineering, computer science reached its current size of 25 FTE with strengths in core foundational areas in 1993. Since then, but particularly over the last five years, the department has consciously broadened the composition of its faculty and embarked on a number of innovative interdisciplinary endeavors that hold great promise for the future.

Among other things, computer science faculty are working with linguists to understand natural languages and human gestures;[1] collaborating with computational biologists in making fundamental discoveries about evolution;[2] partnering with MATRIX, the Center for Humane Arts, Letters, and Social Science On Line, to prepare the next generation humanists;[3] joining with Criminal Justice to design and deliver curricula intended to earn

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[2] C. Ofria (CSE), R. Lenski (Microbial Ecology), E. Torng (CSE), R. Pennock (Philosophy), T. Schmidt (Microbiology and Molecular Genetics), R. Jin (CSE), and D. Ebert-May (Plant Biology)
[3] M. Kornbluh (History), W. Dyksen (CSE), D. Rehberger (WRAC), and P. Knupfer (History)

MSU designation as a center of excellence in homeland security;[4] and spearheading MSU's Cyber Security Initiatives, which involve faculty from seven different colleges.[5]

The Vision: A Trans-Collegial School of Computing and Information

To better exploit the transformational nature of computing, several major universities have established innovative academic units with missions centered on computing and information technology.

Examples include the School of Computer Science at Carnegie Mellon University (1988) and the College of Computing at Georgia Tech (1990), both currently ranked in the top 10 in computer science; and the Donald Bren School of Information and Computer Sciences at University of California Irvine (2002), currently ranked in the top 15 in computer science graduate programs and the top 10 in information technology. These examples are noteworthy in that they center on computer science, rather than library science, and all are considered highly successful programs, which relatively quickly became points of pride for their respective universities.

In the Big Ten, the trend toward housing computing and IT in special academic units is more recent: University of Michigan founded the School of Information in 1996, Penn State founded the College of Information Science and Technology in 1999, and Indiana University founded the School of Informatics in 2000 and the School of Library and Information Science in 2000.

The computing and IT units that center on library sciences have a different focus than those that center on computer science. As these units mature, we will attempt to discern how the different types of computing and information-centric units are impacting their respective universities and the Nation's research agendas. Presently, the most successful of these academic units appear to have at least two things in common: a computing and information centric mission and a leader who reports to a provost.

In a year of self study, review, strategic visioning, and discussions with other faculty and administrators at MSU, we developed a compelling high-level vision for a trans-collegial School of Computing and Information.[6] Briefly, the school would:

- Provide leadership in casting and carrying out a plan for future development of computing and information technology at Michigan State University.
- Foster research and instruction at the intersections of computing with other disciplines.
- Develop flexible organizational and curricular structures needed for innovative cross-disciplinary research and instructional programs.

[4] From CSE: W. Dyksen, R. Enbody, A. Wojcik,; from Criminal Justice: D. Carter, C. DeJong ,and E. McGarell.

[5] Collaborating colleges: Engineering, Natural Science, Business and Management, Social Sciences, Communication Arts and Sciences, Human Medicine, Law. Advisory committee: M. Zaroukian (Human Medicine), P. Whitten (Telecommunications and Arts), P. Yu (Law), R. Calentone (Marketing and Supply Chain Management), D. Gift (Libraries, Computing and Technology), D. Carter (Criminal Justice), E. McGarell (Criminal Justice), R. Enbody (CSE), W. Dyksen (CSE), A. Wojck (chair, CSE).

[6] http://www.cse.msu.edu/Vision2003

This vision does not stem solely from CSE, but is a vision that many colleagues across campus contributed to developing and currently support. Supporters of this vision can be found in the Colleges of Natural Science, Communication Arts and Sciences, Social Science, Criminal Justice, Human Medicine, Business, and Agriculture and Natural Resources. A trans-collegial group of MSU faculty will develop a substantive proposal for such a school in the near future.

A First Step: Expand the Computational Sciences

As a first step, we propose that the University strengthen existing programs in the computational sciences and grow new ones to complement those that already exist. We contend that the College of Natural Science (CNS) is currently the most appropriate home for these programs as CNS has demonstrated flexibility in managing a set of diverse departments with a wide range of funding, research, teaching, and service profiles; and in nurturing a number of successful interdisciplinary programs.

To facilitate this growth, we propose that the Department of Computer Science and Engineering begin a joint reporting relationship to both the College of Natural Science and the College of Engineering effective spring 2005. Moreover, we propose that the College of Natural Science become the lead college for the Department of Computer Science and Engineering also effective spring 2005.

These actions will enable formation of a Faculty of Computing consisting of an inter-departmental group of faculty throughout the College who perform research and teaching in computing. The Faculty of Computing would provide a nucleus for a future School of Computing and Information. Such a school would encompass innovative computational programs in the humanities, arts, business, and other disciplines, in addition to programs in the computational sciences.

Discipline-Based Rationale

One transformational aspect of computing and information has been the integration of powerful techniques of simulation with those of visualization to produce what we now call the computational sciences. Indeed, computation has established itself along side of theory and experimentation as a new and distinct method of scientific discovery.

Michigan State University has a rich heritage of strengths in both computer science and in the natural sciences. Moreover, it already has notable strengths in several areas within the computational sciences, due largely to the Quantitative Biological Modeling Initiative (QBMI), the Cognitive Sciences Program (CSP), the IGERT Program in Cognitive Science, and the Ecology, Evolutionary Biology, and Behavior (EEBB) Program. CSE is an active partner in these multi-disciplinary initiatives and programs.

These highly successful grassroots efforts provide exemplars upon which new computational science programs can be patterned. Additionally, the establishment of the new High Performance Computing Center presents even greater opportunities for computational research and education.

Due to these grassroots efforts, the faculties in CSE and in most departments in CNS have already established cultures that value collaboration. The creation of a full

complement of computational science programs will build on these cultures, strengthening existing collaborations and fostering new ones.

We believe that stronger and more comprehensive programs in the computational sciences will enable MSU to compete more effectively in recruiting computational scientists. Because computational scientists straddle multiple disciplines, traditional departments find them difficult to evaluate, and so pass up very good prospects for recruitment and promotion. In turn, computational scientists are often wary of joining departments with cultures very different from the programs in which they were trained. Fortunately, the College of Natural Science at MSU has already started building an experience-base to draw on in evaluating applicants for faculty positions in the computational sciences, and is also building strong interdisciplinary cultures that should be attractive to computational scientists.

In a meeting on August 24 of chairs, directors, and others at MSU, the Associate Deans for Research of the Science and Technology Colleges at MSU discussed the need for developing a strategic vision for interdisciplinary research with the potential to be funded from NIH. Strengthening and adding computational science programs in CNS will be an important step in the right direction. By bridging strong computational research groups and strong research groups in the health and life sciences, we stand to increase the numbers of researchers at MSU who can successfully compete for funding from NIH and the Life Sciences Corridor.

While demand for traditional computer scientists has declined recently, demand for computing professionals that possess deep knowledge of application domains remains high. Moreover, projections indicate that the demand for IT workers will outstrip production into the foreseeable future, while demand for natural scientists will lag production.[7] Additional bachelor's programs in the computational sciences would therefore attract good undergraduate students who would have career possibilities in their chosen fields without a graduate degree, in addition to feeding graduate programs.

The progressive nature of new programs in the computational sciences should bring added visibility to MSU, both in-state and out-of-state. These programs should attract high achieving students who are inclined towards mathematics and science.

Rationale for Structural Changes

In providing the context for 35 years of teaching and research, Engineering enabled us to build a strong program in core computer science. However, due to the pervasive nature of computing, there currently exist many more opportunities for new collaborations to emerge between CSE and non-engineering researchers than between CSE and engineering researchers. Moreover, the future collaborations that show the greatest potential for high impact are those that involve interactions between computer science and fields like biology, chemistry, and physics, as opposed to traditional engineering fields.

[7] http://www.cs.washington.edu/education/ugrad/current/John.Sargent.TA.ppt

The new reporting lines for CSE will signal a dramatic shift in focus for computer science at MSU. It will re-energize a large number of faculty, both in CSE and in other departments across campus who support a trans-collegial School of Computing and Information but are uncertain if MSU will seriously entertain innovative proposals to foster computing and IT on campus.

This spring CSE will recruit to fill several positions. Consistent with its vision and with that of MSU to promote interdisciplinary health and biomedical research, CSE is targeting life science-informatics as one of two priority areas for recruiting.[8] A multi-disciplinary search committee has been formed. Opportunities to share open positions with other departments will be pursued with a goal of establishing a critical mass of researchers in computing and IT for the life sciences. Because such researchers are not likely to have traditional engineering backgrounds, they can be expected to prefer joining a college of natural sciences than a college of engineering.

By virtue of being situated in CNS, the new computational programs will also draw from a larger and more heterogeneous pool of students than exists in the College of Engineering. By their interdisciplinary nature, these programs are also more likely to appeal to women and minority students than a traditional CSE program.

Joint reporting will facilitate new opportunities while preserving strong existing ties with Engineering. Specifically, CSE would continue to share the Computer Engineering Program with Electrical and Computer Engineering and the CSE major would remain open for engineering students. Students who are already admitted to the CSE major would chose to graduate with an engineering degree or, if they prefer, with a science degree. Prospective CSE students who want a degree in engineering would apply to the College of Engineering, while those who are interested in the sciences would enter the major through CNS. Natural science students who major in CSE need not be required to satisfy any engineering requirements that the Faculty of Computing deems unnecessary for a non-engineering degree. The loosened requirements would enable them to acquire more depth in the sciences or other application domain.

By virtue of spanning multiple colleges, a trans-collegial school presents unique obstacles as well as tremendous opportunities. Overcoming the obstacles will require careful thought and planning. But it also will require "getting to know" the academic cultures of participants from different disciplines. Focusing on the computational sciences will enable the Faculty of Computing to learn to appreciate one another's academic cultures before taking on the academic cultures in more disparate colleges. The multi-disciplinary computational programs and research projects championed by the Faculty of Computing will essentially serve as "pilots" for computational programs bridging many other colleges.

Instructional Programs in Computational Science

Just last year, CSE approved a Ph.D. program proposed by QBMI for a dual major. This program permits a student to obtain a Ph.D. degree with a dual major in

[8] The other is computer security, a National priority area for research in computer science. We and others at MSU envision that the computational sciences and computer security are strategic pillars upon which MSU should build a trans-collegial School of Computing and Information.

Biochemistry/Biology and Computer Science by taking no more than 125% of the typical course load of a single Ph.D. degree, split 60:40 between the two departments. The program centers on a multi-disciplinary research project, supervised by faculty from the participating departments. This basic template has been used successfully for five years for Biochemistry/Physics and Biochemistry/Chemistry Ph.D.'s.

The Cognitive Sciences Program offers graduate specializations to students who are enrolled in master's and doctoral degree programs in Audiology and Speech Sciences, Computer Science, Ecology and Evolutionary Biology, Geography, Linguistics, Neuroscience, Philosophy, Physics and Astronomy, Physiology, Psychiatry, Psychology, Telecommunication, and Zoology. As of this year, it also offers undergraduate specializations to students who are enrolled in any bachelor's degree program at MSU. CSE offers nine courses associated with the graduate specialization and six courses associated with the undergraduate specialization (one of which is cross-listed with Linguistics and taught by J. Hale, an assistant professor with a joint appointment in Linguistics and CSE).

Using these programs as guides and with other departments in Natural Science, we would like to support a fuller complement of undergraduate, masters and PhD specializations in the computational sciences.

These specializations would be crafted largely from existing courses. However, we will need to work with our colleagues in the scientific disciplines on appropriate courses that bridge to computer science. For example, CSE might need to provide a graduate-level programming course for students who are pursuing a computational degree and have no prior programming experience. A graduate level course could cover the programming needed for graduate study in the computational sciences at a faster pace than our current undergraduate courses, so as to streamline the current two-course programming sequence.

Resources permitting, the undergraduate computational programs could also benefit from a 200-level programming course for non-majors. Naturally, the undergraduate and graduate programs in computational sciences will serve as pipelines for graduate and postgraduate research

Research in Computational Sciences

Individual CSE faculty members have already established fruitful research collaborations with members of a variety of departments in Natural Science.

- C. Ofria and R. Lenski (Microbial Ecology) founded a research group on digital evolution, which straddles the boundary between Computer Science and Evolutionary Biology. Other professors working with them include, E. Torng, R. Pennock (LBS/Philosophy), T. Schmidt (Microbiology and Molecular Genetics), R. Jin, and D. Ebert-May (Plant Biology). Collectively, this group has been awarded grants from NSF in excess of $4.6 million over the last five years.[9] They also spearheaded a proposal requesting $18 million for a Center of Experimental and Applied Evolution. Although this proposal was declined, it precipitated the formation of an exceptional

[9] including a $4 million grant for which Lenski was PI and co-PIs were from Caltech and Yale, and Ofria was funded as senior personnel pending completion of his PhD

interdisciplinary team—E. Goodman (ECE), C. Ofria (CSE), R. Lenski (Microbial Ecology), L. Kuhn (Biochemisty), and R. Pennock (Philosophy)—which will continue to pursue such a center.

Some nine PhD students are working in digital evolution, many with dual majors. These students include five in CSE—two also working on majors in EEBB, another working on a major in Microbiology and Molecular Genetics, and a third already with a PhD in Chemistry; three in the Zoology Department—all three also majoring in EEBB; and one in the Philosophy Department—planning a dual major in CSE. The digital evolution group has involved a half-a-dozen undergraduate students in research, several of whom later chose to pursue graduate degrees due to their research experiences.

- A. Jain and S. Dass (Statistics) have been working together in fingerprint matching for the past two years. They recently received a 3-year NSF ITR grant to support their work.
- L. Xiao is collaborating with M. Feig (Biochemistry and Molecular Biology) on using distributed computing technologies in developing a scalable public repository for biomolecular conformational sampling data from computer simulations. A proposal was recently submitted to NIH to fund this research.
- B. Cheng, P. McKinley, S. Kulkarni, and J. Weng are collaborating with S. Gage and others in the Department of Entomology. Using high assurance software and autonomic computing mechanisms, this group is constructing robust, self-managing sensor networks for ecosystem monitoring. While not yet funded, these researchers have produced a full NSF proposal.
- L. Jackson (Psychology), F. Biocca (Telecommunication), and J. Chai recently submitted a proposal to NSF to design and pilot a model graduate program at MSU in human-computer interactions (HCI).
- A collaboration between R. Enbody and D. Tomanek (Physics) resulted in a patent on uses and production of nanocapsules containing charged particles.
- J. Chai and J. Hale (Linguistics/CSE) are active faculty in the MSU IGERT Program.
- J. Chai, J. Hale (Linguistics/CSE), W. Punch, J. Sticklen, G. Stockman and J. Weng participate in the Cognitive Sciences Program.
- C. Ofria, W. Punch, E. Torng and S. Pramanik are active in the Quantitative Biology and Modeling Initiative. The first three serve on the QBMI executive committee.
- CSE is also playing a larger role in the Ecology, Evolutionary Biology, and Behavior (EEBB) Program and plans to become a member department of this program.
- CSE is extending offers of 0% courtesy appointments to colleagues in CNS (and in other units at MSU) with expertise in computing and interests in pursuing joint programs and collaborative research with CSE faculty. In CNS, offers to R. Pennock (LBS/Philosophy) and Sarat Dass (Statistics) have been accepted; offers to R. Lenski (Microbial Ecology) and W. Bauer (Physics/Cyclotron) were recently extended; and

offers to L. Kuhn (Biochemisty), T. Schmidt (Microbiology and Molecular Genetics), D. Ebert-May (Plant Biology), and S. Gage (Entomology) are currently planned.

More important than the existing collaborations, however, is the potential for new ones to arise in bringing together a critical mass of talented people intent on working as a team on computing and information related programs of research and teaching.

Conclusions

Since its inception in the early 1960's, the discipline of computer science has transformed itself and the world. Across the country, leading universities have established high level academic units focused on computing and information.

Computation—simulation combined with visualization—has established itself along side of theory and experimentation as a strategic asset in the portfolio of the natural sciences.

As a first and immediate step, we propose the establishment a multi-disciplinary Faculty of Computing within the College of Natural Sciences. The charge for this Faculty would be to strengthen and grow a wide range of programs of research and education in the computational sciences.

To this end, we propose that the Department of Computer Science and Engineering report to both the College of Natural Science and the College of Engineering with the College of Natural Science serving as the lead college effective spring 2005.

These actions will lay the groundwork for a more comprehensive School of Computing and Information. A proposal for such a school will be prepared by a small focus group that spans multiple colleges, including Natural Science, Communication Arts and Sciences, Social Science, Human Medicine, Business, and Agriculture and Natural Resources.

We expect that Michigan State University will eventually establish a high level academic unit centered on computing and information. At that time, we expect that the Faculty of Computing will be part of the founding faculty of such a unit. However, in the meantime, we believe that proceeding immediately with our proposed plan for the computational sciences would best serve the strategic interests of CSE, as well as the entire University.