Wisconsin in the Information Age

Executive Summary

Computing has transformed the world. It has become central to virtually all aspects of society. Computing has also profoundly affected UW-Madison. Many science disciplines at UW-Madison, ranging from astronomy to zoology, now need extensive computing and data processing support. There is high demand for workers with these skills, so students are flocking to computing courses. As a result, computer science has become the most popular major on campus, and new programs such as an undergraduate major in data science are being created to at least partly meet the exploding demand.

Computing is also increasingly central to Wisconsin's economy. It transforms existing sectors and creates new ones. Sectors critical to our economy, from manufacturing to agriculture and insurance, are becoming more data-driven. Other sectors profoundly affected by computing include health care, medicine, and biotechnology. Computing is generating tens of thousands of jobs in Wisconsin, many of which currently go unfulfilled as we are unable to educate enough workers. Computing is also changing the way people work, shop, and relax, profoundly impacting both urban and rural Wisconsin.

In response to these accelerating changes, in January 2018, Chancellor Rebecca Blank authorized the creation of a 12-person UW-Madison Working Group on Computing, drawn from campus, alumni, and industry. The group was charged with exploring the impact of computing on UW-Madison and the state, and making recommendations to help UW-Madison educate students and retain its leadership in computing, artificial intelligence, big data, and related fields.

Given the broad nature of this charge, we use the term "computing" in its broadest sense here and throughout, including computer, data, information science and related disciplines, and usages of computers for automation, analysis, and related tasks. Investigating applications of big data and artificial intelligence led us to look at what our peers and UW-Madison are doing in data science, which was born out of big data. While computing and data science are intrinsically related, they are not the same thing. However, for ease of exposition, we have used these terms interchangeably throughout this report.

Central to the working group's efforts and conclusions is the Wisconsin Computing Idea, described briefly in this executive summary and greater detail in the full report. The concept of *core, connections,* and *enrichment* introduced therein is a recognition that the disciplines of computing, data science, and information science are practiced virtually everywhere across the UW-Madison campus. No entity can "own" the application of these disciplines, in the same manner as no one "owns" math or physics. Yet, the existence of a Core, just as in math and physics, is needed to advance the teaching and research of the discipline itself. Connections link the campus and facilitate the proliferation of these new sciences across campus to ensuring knowledge and sharing in computing and data science education and research. Enrichment introduces the need to teach and research the societal impacts of computing and how the applications of big data, artificial intelligence, robotics, and others intersect with the social sciences.

The working group extensively discussed computing in numerous face-to-face meetings, phone calls, and emails. We reached out and interviewed the current and former leaders of our country's top academic computer science, data science, and information science programs. We held extensive discussions with administrators, educators, and researchers on the UW-Madison campus. We had comprehensive discussions with the Wisconsin business community and government. We also spoke with numerous students at the undergraduate, graduate, and professional levels, in many different disciplines.

The World of Computing and Data Science

This report summarizes the observations made by the working group. It proposes a vision of computing for UW-Madison and the state of Wisconsin, makes recommendations, discusses the challenges, and proposes action items. Specifically, we begin by making the following observations:

- *Computing has become central to virtually all aspects of society.* Computer software is "eating the world,"[i] causing significant upheavals throughout society, obviating some jobs, transforming others, and creating entirely new types of work. Five of the ten largest companies in the world are computing-centric, three of which (Google, Amazon, Facebook) did not exist 25 years ago.
- *Data science is increasingly central to society.* A large part of the computing revolution involves data: it has now become possible to capture a large amount of data and analyze it to infer insights. Data science has emerged to address this need and has, in turn, fueled revolutions in other areas, such as artificial intelligence, biotechnology, virtual reality, and many sciences. While data science straddles many fields ─ notably statistics, computer science, and information sciences ─ it is transforming practically every other discipline across academia. It also profoundly affects industry, government, and society at large.
- *Computing is at the center of Wisconsin's economic growth.* To retain our economic competitiveness and high standard of living, Wisconsin needs to train its current labor force, in sectors ranging from agriculture to manufacturing and tourism, in computing and data skills.
- *Computing is critical to the future of UW-Madison.* UW-Madison will substantially enhance its powerful economic impact by boosting its computing and data science prowess, which will catalyze the regional economy. Investment now is key to enabling UW-Madison researchers across all disciplines to be more competitive and raise more funding, to educate tomorrow's leadership, to attract new kinds of investment, and to build confidence in the future of the Wisconsin Idea.
- *Our peers have rapidly moved to take advantage of the computing and data revolution.* Peers recognize the need for strong, coordinated leadership across related academic units involved with computing and data science. Their administrative load has increased to provide needed resources and education to campus, to collaborate across disciplines, and to interact effectively with potential donors and industry. UW-Madison is not a first mover in elevating the computing agenda and substantially lags behind our peers in developing data science initiatives.
- *It is critical that we act now.* Student demand for computing and data science education has sky-rocketed while recruiting and retention of quality faculty has become increasingly challenging. We agree with the observation made by a similar working group at Cornell University that *the computing revolution is likely to reorder the reputation of major American universities, and that those coming out at the top will reap enormous benefits as society reacts to this revolution.*

Computing at UW-Madison

One of the world's leading universities, UW-Madison has a unique position among its peers with our breadth of research and teaching. The existence of leading programs in the College of Agricultural and Life Sciences, the School of Medicine and Public Health, the School of Veterinary Medicine, the College of Letters & Science, the College of Engineering, and the Wisconsin School of Business creates a unique opportunity for UW-Madison to excel in computing and data science across a broad multidisciplinary spectrum. Of our peers in the top 15 computer science programs, few offer the breadth excellence that UW-Madison does.

Changes are happening at an unprecedented pace, demanding flexibility and nimbleness to transform programs and initiatives quickly. The challenge is to have clear leadership from the top coupled with strength within the core computer, data, and information science units on campus. Incentives need to be in place to support and encourage collaboration and cooperation across disciplines. UW-Madison currently is engaged in expansion through professional programs, bringing new revenue to grow faculty and staff. While useful as a short-term strategy, the sustainability of

staffing professional program revenue for the long term, particularly across computing and data science, requires a well-planned long-term strategy.

Trends with Our Peers

The working group collected information on our top-15 peers and surfaced these trends:

- Effective leadership of computing and related programs is the most often cited reason for success in accelerating learning and research initiatives in computing and creating interdisciplinary programs of excellence in information and data science.
- Higher education broadly has been struggling to handle the explosion in demand for computing. The number of bachelor's degrees awarded nationally in computer and information science has increased by 74 percent since 2009, compared to a 16 percent increase overall[ii].
- There has been a significant investment in data science. Research institutes are receiving the most funding. Curricula and degrees are becoming more prevalent.
- Fundraising for computing and related programs is more accessible than fundraising for most non-computing disciplines. Many foundations and a higher proportion of wealthy alumni are contributing to expanding education for the highest in-demand professions. Witness our intrastate peers: UW-Milwaukee and Marquette recently announced a new $39M data science initiative with the support of industry, and MSOE announced a $34M donation from one of its alumni for a building and programs in computational science.

Peer Investment

In the past decade, as computing has increasingly shaped every aspect of society, many states and universities have made significant investments in their computer science, computer engineering, statistics, biostatistics, and information studies.

WARF carried out a study for the working group on facility investments of the top four rated computing programs and the next seven public universities. *All eleven institutions launched CS-related capital projects within the past fifteen years. All but two (Carnegie Mellon and MIT) have constructed a major building within the last five years.* The four top-ranked schools have spent an average of $136 million, and $16 million within the past five years, on CS capital expansion projects. The other seven schools have spent an average of $121 million over 15 years and $98 million in the past five years. By comparison, the CS building at UW-Madison was built in 1987, more than 30 years ago, and has 69,000 square feet in space, which is about 65% of the space of our peers.

The median faculty numbers for the top 10 programs is 75, while Madison currently has half that. The CS department is approved to increase to 50 staff, although special efforts will be needed to achieve that. It will not be done in a status quo scenario, as the Wisconsin faculty size has been flat for 20 years.

It is a testament to the quality of the CS program at UW-Madison that it has retained a relatively high rank without anywhere near as much spending. This situation is not sustainable, however, and indeed the ranking of the CS department has dropped in recent years, from #9 in the early 2000s to #11 in 2007 and #13 in 2018.

The Wisconsin Computing Idea

Everything a university does should aim at addressing the needs of society through teaching, research, and outreach. That is a central component of the Wisconsin Idea but not the heart of it. The heart of the Wisconsin Idea is that UW-Madison —*this* University— should address the needs of *all* citizens of *this* state. Our identity is shaped by our devotion to Wisconsin and our determination to define that devotion as serving every single person within our borders. That identity must form the bedrock of any analysis of computing at UW-Madison. More than a changing discipline or shifts in rankings, computing entails a societal transformation that is already affecting the lives of every Wisconsinite.

Building on the above observations, we propose *the Wisconsin Computing Idea, a vision of computing for UW-Madison and Wisconsin. This vision holds that computing is critical to our university and the state, that UW-Madison will take decisive and bold actions to lead the computing revolution, and that advances in computing on this campus will benefit all corners of our great state.*

Three pillars underlie this vision:[iii]

- ● **The Core:** We will grow a core of excellence in computing and data science at UW-Madison, with exceptional visibility both outside and inside the state. This core will consist of computing- and data-centric departments such as computer science, statistics, and the iSchool. Its primary goals are to attract, retain, and grow computing talent and resources; to go deep into research, education, and development in computing and data; and to coordinate these efforts on campus and throughout the state. This core will not be the university's only home for excellence in computing, as areas such as computer engineering, bioinformatics, and others will also develop deep competencies in computing related to their fields.
- ● **The Connections:** As the Information Age progresses, computing and data literacy need to exist in practically every area of society. At UW-Madison, this translates into a need for virtually every academic discipline to develop such literacy. Collaborative strategies will be established to ensure students and researchers have access to computing education and resources needed to prepare them for the demands of an information-driven society. Such collaborations will include shared courses, joint research efforts, consulting, joint faculty appointments, joint degree programs, professional programs, infrastructure support, workforce training and recruiting, and more.
- ● **The Enrichment:** The Information Age presents fundamental challenges and opportunities in many areas, including social justice, ethics, privacy, inclusion and diversity, human-centered design, social policy, and more. We will develop new competencies in these evolving disciplines of applied computing, and work with the social sciences, business, and other disciplines to create curricula and programs that will positively impact how society deals with the changes of the Information Age.

Realizing the Vision

UW-Madison is not a first mover in responding to the demands of the Information Age. The working group analyzed different models from the top 15 computing programs nationally, across computer science, library and information sciences, statistics, and computer engineering. We placed this analysis in a Wisconsin context, desiring to take advantage of the breadth of our multidisciplinary excellence, the economic needs of the state, the current collegiate home of faculty in these areas, and the near- and long-term opportunity for differentiation and excellence.

The combination of multidisciplinary breadth and pervasiveness of computing and data science offers UW-Madison a unique opportunity to establish leadership in computer, data, and information sciences as core disciplines and across campus in virtually every domain. To realize this opportunity, straightforward yet bold changes need to be enacted.

We divide our recommendations into near-term and medium-term, to make clear the need to move quickly and also put in place a lasting and effective structure. The working group near-term recommendations are:

- ● *Fundamental to realizing the Wisconsin Computing Idea at UW-Madison is the appointment of a computing/data science leader.* This leader will most effectively be able to drive change, develop cross-campus computing curricula and programs, create high-profile funding opportunities (e.g., much like Engineering's recent success with Foxconn), lead the coordinated recruitment of faculty and students, and elevate the reputation of UW-Madison as a computing leader globally.
- ● *The Department of Computer Sciences, the Department of Statistics, and the Information School should be brought closer together, in a formal structure consisting of three distinct departments within L&S.* This entity should be a school or equivalent, with the new leader serving as director. The recommended name is the School of Computing and Data Sciences (SCDS), which would send a strong signal that Wisconsin is committed to both computing and data science, not just in that school but across the university and the state.

- *Create a new task force comprised of leaders involved in computer, data, and information sciences.* This group will propose detailed plans and action items to create the new entity, led by the new director.
- *Establish a set of milestones.* Examples are target faculty numbers, new curricula, new majors and certificates, new graduate programs, professional masters programs, new cross-college degrees, student levels, teaching ratios, fundraising, and more.
- *Establish a computing and data science "steering committee" to exist indefinitely.* This senior-level board would meet regularly, ensuring that the SCDS is responsive, effective, and achieves its milestones. The board would agree to a roadmap for computing and data science that will help mobilize faculty, recruit talent, engage with industry and government, and rally donors and supporters.

In the medium term, our recommendations are:

- *Upon achievement of the milestones, the working group recommends creating a decanal entity for computing at UW-Madison, which will function as the "core" pillar of the Wisconsin Computing Idea.* It is unclear at this time what structural name can be applied, so for this report, we chose to borrow a term from Cornell. Specifically, we recommend creating a Faculty of Computing and Data Science (FCDS)[iv], whose dean reports to the provost. Given the pervasiveness of computing, data science, and information science and its importance to the state, the working group agreed that this is the most effective model.
- *Unlike a college, the FCDS would not admit undergraduates nor grant degrees. It will develop and teach the curriculum and perform research within its core functions of computer science, statistics, data science, and information and library science.* The dean and faculty of the FCDS would be incentivized to partner with other colleges at UW-Madison to develop multiple educational programs, such as majors, minors, and concentrations in computing and data sciences, then offer these programs to students enrolled in those colleges. The result would make education in computing accessible to all students. A new funding model would need to be developed, based on models already in existence in most other universities. Initial discussions with university finance have indicated that this is feasible.
- *The FCDS would work with the campus, stakeholders, and constituencies to significantly build up the three pillars -- core, connections, and enrichment -- of the Wisconsin Computing Idea.* The FCDS will not own all computing nor data science activities, but rather facilitate initiatives campus wide.

The working group realizes that change of this magnitude requires careful consideration, debate, and discussion within the faculty, administrative and community circles. Additionally, a critical mass needs to be established in key areas like faculty size, curricula development, and funding. Drawing primarily from what we learned from Cornell, Michigan, Washington, and UC-Berkeley, and mindful of the need to act quickly in the current fast-changing landscape of computing, we believe that this path is feasible and would set UW-Madison apart while serving to meet the demands for computing and data science in Wisconsin.

Financial Implications

The working group is conscious of the tight financial conditions that UW-Madison is operating within, and seriously considered this constraint in deriving our conclusions. Both of the proposed SCDS and FCDS options are "light" relative to several other possibilities, including creating a full college. Since admissions and degree granting remain in other colleges (L&S, Engineering, Agriculture and Life Sciences, Medicine, Business), staffing costs for a college level unit are optimized.

Notwithstanding, a significant investment needs to be made to increase faculty levels; establish institutes for collaboration and innovation; construct a new facility to house faculty, develop curricula and teach larger volumes of students and offer collaborative workspace; establish and administer professional masters programs both online and on campus, and hire world-class leadership. A commitment of this magnitude demands a concerted effort by all stakeholders including the university, the state, industry, faculty, donors, and alumni.

The College of L&S has done a preliminary budget estimate of $125-150 millions for a facility. While a large sum of money, our peer institutions have been successful at raising monies for new buildings in computing through partnerships of private money, foundations such as the Bill and Melinda Gates Foundation, corporate gifts and state matching funds.

Closing

We realize that the recommended changes are not easy to undertake in a university. However, we believe that the pervasiveness of computing and the speed of change our society is experiencing make it critical to explore new, more flexible and interdisciplinary, structures and to take actions now. *Like all distinguished universities, UW-Madison must continually renew itself to adapt to changing realities.* Thus, we call on our colleagues across this great campus, as well as our friends, alumni, and supporters in the rest of the state and across the world, to join forces and "will into being" these critical changes. Together we can help our university and state prosper in the Information Age, and leave a significant, lasting, and meaningful legacy for future generations of UW-Madison students and faculty, as well as for all Wisconsinites.

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[i] "Why Software Is Eating The World", M. Andreessen, The Wall Street Journal, August 20, 2011.

[ii] "Assessing and Responding to the Growth of Computer Science Undergraduate Enrollments", National Academies Press, 2018, https://www.nap.edu/download/24926#. The study is of not-for-profit institutions.

[iii] The working group acknowledges borrowing the concept of "Core, Connections, and Enrichment" from UC-Berkeley's "Data Science Planning Initiative - Faculty Advisory Board Final Report", 2016 summarized here https://www.stat.berkeley.edu/~binyu/ps/FAB-Summary2016.pdf

[iv] The name is borrowed from Cornell, should be discussed, and can be changed.