The Case for a College of Computing

at the University of Wisconsin-Madison

February 17, 2017

Version 2.7

Executive Summary

- Computing is changing the world, and is increasingly central to our state's economy.
- Our state needs a computing agenda, or risks falling behind in this increasingly digital, computing centric world.
- We need an entity that will help develop and implement this evolving computing agenda. Due to its leadership in key areas of computing, as well as others, UW-Madison is uniquely positioned to act in this capacity.
- In turn UW-Madison needs an entity that will cover all computing aspects and be at the heart of the campus. A College of Computing (CoC) is the right way to establish such an entity.
- We can seed and grow the CoC with the Computer Sciences Department. Faculty in CS are capable and willing.

Computing is Changing the World

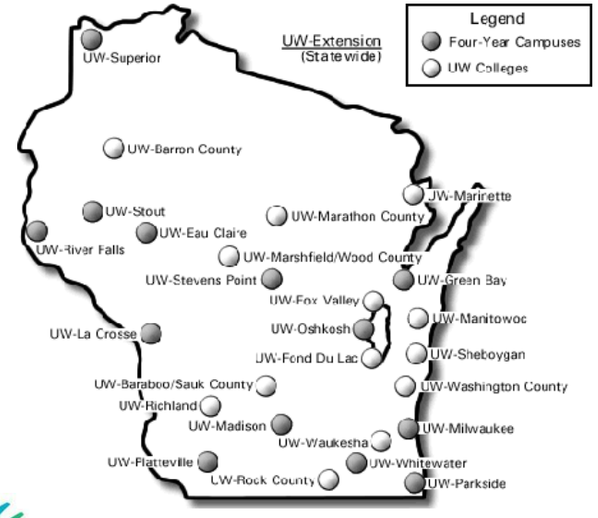
- **Permeating all aspects of society**
  - Everyone now walks around with a powerful computer in their pocket!
- **Moving very fast**
  - **Major trends accelerating & converging, each new trend takes less time to appear**
  - Internet, cloud computing, mobile devices, social media, big data, …

- **Expanding at an unprecedented rate**
  - Data science, artificial intelligence, virtual reality, Internet of Things, autonomous ….
- **Causing major upheavals**
  - **Automation is accelerating, killing jobs; e-commerce killing off bricks and mortals**
  - Five of the top-10 largest companies in the world are in computing, three of which did not exist 25 years ago (Google, Amazon, Facebook)
  - **The world's largest transportation company owns no vehicles (Uber), the world's most popular media company creates no content (Facebook), the world's largest accommodation provider owns no property (Airbnb), the world's ……..**

No other field has caused so much change so fast.

And we are only at the beginning, with more dramatic changes coming …

Computing is Increasingly Central to Our State's Economy



- **Transforming existing sectors**
  - UW system is the major **research & education** driver in the state, pumping billions per year into the state economy ($15 billions alone by UW-Madison); **yet computing is increasingly critical to research and education in all fields at UW**
  - **Manufacturing** is increasing data driven, and so is the **service sector** (such as insurance)

Johnson Controls

AMERICAN FAMILY INSURANCE®

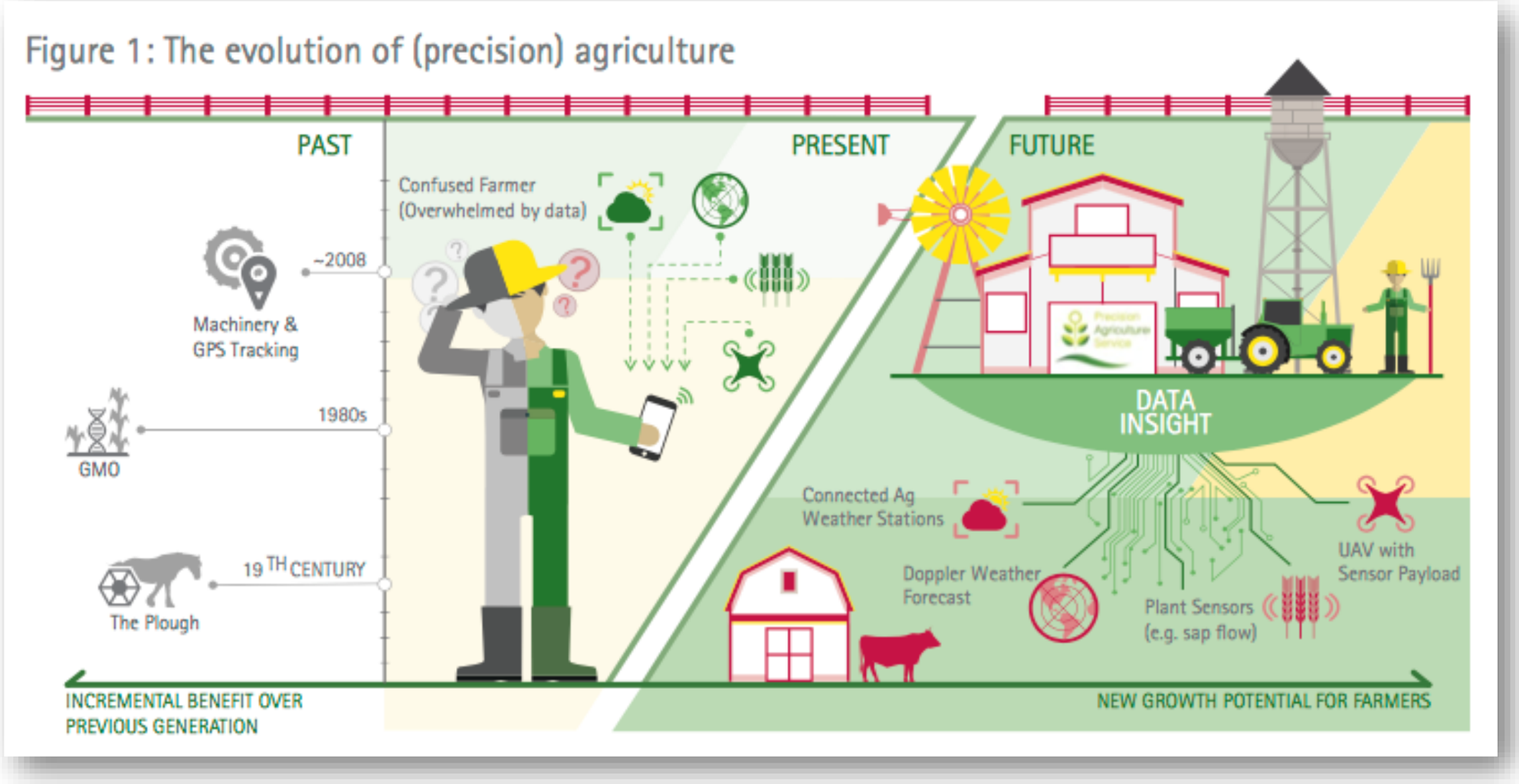
  - **Agriculture** is the same

*"Five emerging trends have the power to transform Wisconsin agriculture in coming years, and **increasing computer capabilities plays a role in four:** big data, artificial intelligence, autonomous vehicles and the sharing economy."*

From "Tech and social trends poised to transform agriculture", by John Shutske, in "Wisconsin State Farmer", Jan 31, 2017

  - **Healthcare, medicine, transportation, ……..**

Agriculture as an Idiom for Transformation



Digital Agriculture: Improving Profitability
Accenture, 2015

Examples of Upcoming Transformations

- Autonomous vehicles and intelligent highways
- Smart cities
- Virtual hospitals
- Personalized medicine
- Home/service robots
- Interactive machine tutors for education
- And many others

Computing will transform many aspects of everyday society!

In the process will disrupt existing structures and create new opportunities!

Computing is Increasingly Central to Our State's Economy

- **Growing new sectors**
  - **Information Technology** itself (including health care and others) is a booming sector in Southwest Wisconsin, generating tens of thousands of jobs
    - for example ~ 10,000 at Epic
    - with Google, Microsoft, others ….
  - **Biotech** is increasingly becoming reliant on computing
  - **Entrepreneurship** heavily skewed towards computing

Top markets for tech employment growth, 2001 vs. 2015

Examples of recent companies: Nordic, EatStreet, PerBlue, Adobo, Ionic, Murfie, HealthMyne, Propeller Health, VidMaker, and more

Attracting disproportionate share of new venture capital

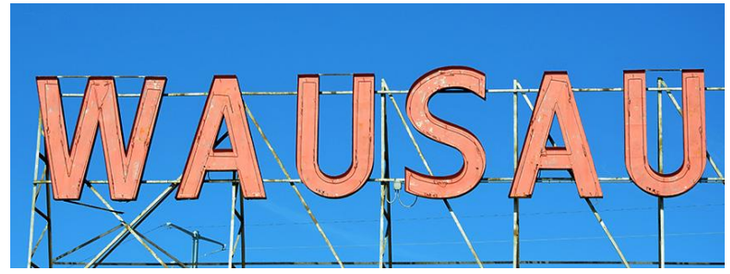
35/128 deals in IT ($58/$209 million)

45/128 in healthcare ($85/$209 million)

of which 21/45 are CS-related ($30 million)

Computing is Increasingly Central to Our State's Economy

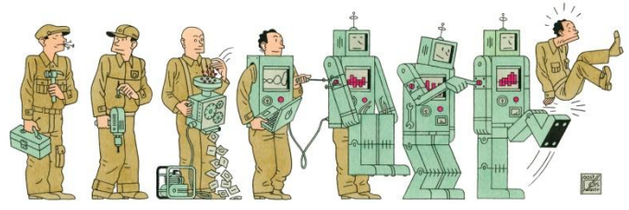
MCIS Marshfield Clinic Information Services



- **Generating many jobs (that go unfulfilled as we can't educate enough)**
  - **"IT worker shortage in central Wisconsin near 'crisis'"**, by Dave Daley, wpri.org
  - **"We can't graduate enough students to fill the demand right now"**, in "Companies looking for more workers in IT field", Wausau Daily Herald, April 15, 2015.

- **Changing the way we work, shop, and relax**
  - **"Connecting rural Wisconsin: the economic necessity of broadband"**, by the Wisconsin Technology Council, Nov 8, 2011
  - broadband in rural Wisconsin helps improve existing business, connect them to new customers, foster new businesses, improve tourism, among many other benefits

- **Creating disruptions that we must handle**
  - Job loss in manufacturing due to automation, company relocation
  - E-commerce killing off local shops, draining local spending power



Our State Needs a Comprehensive Computing Agenda

- How can we use computing to super-charge our economy?
- How can we help all aspects of our economy, from research & education, to manufacturing, to agriculture, and beyond?

- How can we foster new computing-based sectors, such as IT, health care, biotech?
- How can we create, grow and retain computing related jobs in the state?

- What job related effects computing will have on our state and our middle class? What can we do to address those?
  - For example, can we help retrain those losing jobs to automation for other jobs in the digital economy?
- How can we educate our work force much better in computing to compete?

If we are not pro-active, we risk falling behind in this increasingly digital, knowledge-based, computing-centric economy

We Need a "Central Entity" to Help Develop and Push This Agenda

- We need an "entity" that will provide the sustained "brain power" required to develop & implement an evolving computing agenda for the entire state
- Due to its leadership in key areas of computing, as well as other areas, UW-Madison is uniquely positioned to act in this capacity
- In turn UW-Madison needs an entity that will cover multiple aspects of computing and be at the heart of the campus. A College of Computing (CoC) is the right way to establish and sustain such an entity

Why Central?

- **Can easily interact with all parts of UW-Madison, and more broadly with external stakeholders**
- **Can more easily impact UW-Madison and the rest of the state**
- **Can be easily involved in important decisions as computing proliferates**
  - education, training, outreach, etc.
- **Outsiders, decision makers, those with power and ability to execute need an easy path for access/reach to such a critical discipline**
  - e.g., big donors, business people from all over, government agencies, startups
- **Can gain sufficient visibility outside the state, send a message that Wisconsin and UW-Madison are very serious about computing**
  - Critical to attracting the extremely mobile talent that will be key for Wisconsin's and UW-Madison's long-term well-being

Why College (or College Level)?

- **CS is becoming (or already is) a driving enabler across a large part of the university, and is critical to the economic well-being of the state**
  - like (School of) Business and (College of) Engineering
- **To have the highest impact, CS must be part of the conversation at the top-most organizational level at the university**
  - Not one of ~40 departments in one of 11 colleges or college-level entities
    - and further in one of multiple divisions within one college
    - with cultures that are very different from that of a rapidly growing discipline with a very mobile workforce
- **To better be able to fulfil its mission to the state and the university, it must be more visible, externally and internally**
- **And have the freedom to be flexible and adaptable and to deliver**
  - without constraints of intermediate levels of bureaucracy
  - without constraints of bigger entity with potentially different goals

A College of Computing is Also Critical for UW-Madison

- **The same arguments for the state apply to UW-Madison**
- **Computing is now pervasive, increasingly critical to research and education in all fields at UW**
  - **data science is increasingly being viewed as a fourth mode of scientific discovery, on par with theory, physical experimentation, and computational simulation and analysis.**
- **Computing is now an accelerant**
  - using it we can turbo-charge our research enterprise, make far reaching discoveries, amplify our impact, and **generate far more research funding**
- **Computing is now literacy**
  - opens doors to high-paying jobs
  - **computing knowledge useful in virtually all disciplines**
- **A CoC can help this matter tremendously**

Important for UW-Madison's Research Enterprise

- **Increasing role of data and computing in UW's core funding base (NIH)**
  - Will accelerate with transformations in biology, healthcare, medicine, ……
- **Major new initiatives will likely have a significant data/computing component**
  - E.g., Brain Science
  - **Will a major initiative not have an important data/computing component?**
- **Funding opportunities for computing-heavy initiatives likely to continue to increase**
  - Security, artificial intelligence, autonomous vehicles, robotics, big data, cyber-physical systems, IoT, and others
- **Excellence in computing critical for future research at UW-Madison**

Additional Benefits for UW-Madison

- **A visible and pre-eminent CoC at the heart of UW-Madison**
  - Enhances capabilities of others on campus
  - Serves as a potential recruiting tool for others
  - Further, others across campus benefit from:
    - Indirect costs of increases research revenues
    - Increased educational revenues
    - Increased revenues from other sources (e.g., intellectual property and entrepreneurship)
- **Engaging stakeholders who want to see new things**
- **Enhanced ability to attract corporations to have presence in Wisconsin**

A vibrant and growing CoC at the heart of UW-Madison will expand the pie, with benefits across campus and the state as computing proliferates

We Are Not the First to Discover This …

- **Some universities set up CoC in the 90s and 2000s**
  - they have done exceptionally well
  - Why have Disney/Uber/others set up facilities in Pittsburgh?
  - Georgia Tech has risen into the top ten, and attracts increasing research funding
    - more federal expenditures than UW-Madison in 2015!
- **Other universities have done the same recently**
  - U Mass at Amherst, Pittsburgh, …
- **And many are currently considering doing so**
  - e.g., U of Maryland, UC-Berkeley, UC-San Diego, U of Washington, U of Illinois, others …..
- **Closer to home, a lot is happening**
  - Indiana has set up a state-centric computing agenda, with tens of millions of investment in Indiana U and Purdue U
  - Illinois is exploring CoC
  - Michigan has set up a huge Data Science Institute, with special funding

Vision of a CoC

- **For computing**
  - Leadership in **computing, pushing boundaries of CS in research/education/service**
    - A vibrant and rich environment for computing, attracting people far and wide
    - Leading presence in the Midwest and the world
- **For UW-Madison**
  - Leadership in computing-related transformations of academic disciplines across UW-Madison
    - At the center, without boundaries and walls
  - Leadership **in creating computing infrastructure to power research & education**
- **For the state**
  - Leadership in **educating the students/citizenry of Wisconsin in computing**
  - Leadership in enhancing and sustaining the economic well-being of the state
    - workforce development, fostering and nurturing entrepreneurship, enhancing capabilities of existing companies
  - Partnering with and **helping a broad range of sectors of the state economy**
  - Partnering with others to understand and address the societal impact of computing transformations
  - Be **the computing face of UW and the state** (e.g., for donors, external people)

Realizing the Vision

- **An "octopus" organizational structure**
  - With "tentacles" reaching far and wide into other colleges and schools
- **Attracting a diverse set of outstanding people**
  - Faculty, research professors, teaching faculty, lecturers, research scientists, programming staff, liaison/outreach staff, funding raising staff, etc.
- **Cultivating world-class leadership in computing**
- **Powering research and education at UW-Madison and beyond**
- **Training and creating more high-tech jobs in Wisconsin**

Organizational Structure

- **CS department at the core (perhaps absorbing current computer engineering)**
  - the head of the octopus
- **Other CS-subject departments**
  - e.g., machine learning, robotics, HCI, etc.
  - grow via hiring (both tenure-track and research faculty track)
- **Other departments (e.g., CS and bio/medicine/health care, CS and X)**
  - tentacles reaching out to other disciplines/entities
  - initially staffed with cross-appointed zero-time faculty (existing or new)
  - growing with new hires directly into departments
- **Centers/institutes of specialization**
  - Data sciences, information security, CHTC, WISDOM, etc.

Attracting a Diverse Set of Outstanding People

- Tenure-track faculty
- Research faculty
- Research scientists
- Teaching faculty
- Lecturers
- Staff (programming, accounting, project management, etc.)
- Lab and its personnel
- Graduate students (regular, professional, long-distance, etc.)
- Undergraduate students
- Students outside CS
- Liaison/outreach/fund raising people
- …

Attracting a Diverse Set of Outstanding People

- **Grow CS faculty to accommodate the continued expansion of the field**
  - Continue expertise growth as the field of CS grows
    - In its lifetime of ~ 50 years, new areas of CS every decade
  - Perhaps spread over multiple "departments"
    - Like other CoCs (CMU, Georgia Tech, Cornell)
    - To facilitate interaction and overlap with other disciplines
    - To maintain units at a reasonable size for cohesiveness
  - **Enablers:** State of Wisconsin, UW, differential tuition, more students, others ….

- **Easy and flexible movement of faculty currently (and in future) in other units/colleges**
  - Critical to bootstrapping CoC and to long-term intellectual growth of CoC as well as others
  - **Enablers:** Senior administrators in UW-Madison

Attracting a Diverse Set of Outstanding People

- **Research scientists and research faculty**
  - Amplify research activity and funding
  - Will need to recruit and nurture
  - **Enablers:** department share of patent royalties and other funds to jump start, maintain, and sustain research activity (e.g., safety net)

- **Graduate students**
  - **Enablers:** department share of patent royalties, private donors, others

Providing World-Class Leadership in Computing

- **Strengthens and expand strong research areas**
  - Architecture ➔ architecture + hardware + robotics + IoTs (focusing on the physical part)
  - Databases ➔ databases, data management, data science (focusing on the data part)
  - Systems, networking, PL ➔ grow and expand
- **Grow new research CS areas**
  - Identify based on (a) where the field is going, (b) impacts on our economy, and (c) strengths of UW-Madison and Wisconsin
  - Candidates include security/privacy, AI/ML, cyberphysical systems (including robotics, IoTs, embedded systems, virtual reality), big data and data science, HCI
- **Seed and grow new "transformative" areas**
  - For example, strategic alliance on bioinformatics and medical informatics with BMI
  - Other domains critical to our state and UW-Madison, such as agriculture, biochemistry, manufacturing, health care, bio tech

Broad base, selective "super deep" areas in CS and pioneering activity in knowledge creation and transformation

Powering Education at UW-Madison and Beyond

- **Education in the 21st century also increasingly requires computing literacy**
  - At all levels, from pre-college through advanced graduate
- **Proliferation of computing will call for new degree programs at both the undergraduate and graduate level**

CoC Education Goals

- Increase computing literacy for other "classical" majors on campus
- New undergraduate degree programs along the "tentacles"
- New graduate and professional degree programs along the "tentacles"
- Provide special courses, bootcamps, tutorials to the UW community on important or timely topics, such as Big Data, computing security, data science, career opportunities in computing, etc.
- Partner with other UW campuses and higher education institutions across the state to work on education initiatives, such as online BS programs in computing
- Facilitate initiatives to increase CS education at pre-college institutions

Contributing to Wisconsin's Economic Well-Being

- **Training more high-tech workers**
  - Double the number of students graduating with BS/MS/PhD degrees in CS by 2025
  - Double the size of our professional programs by 2025
  - Evolve education and training as knowledge advances
- **Fostering economic development and growth**
  - Accelerate startup creation and development by partnering with private entities
  - Closer and more direct engagement with more established companies
  - Resource for educating companies about the changing computing landscape
- **Facilitating recruitment and retention of high-tech talent**
  - Foster programs for internships and employment
  - Foster a thriving high-tech ecosystem

Why CS is Well-Suited to Lead

- **Seeding and growing the CoC with the Computer Sciences Department**
  - Which should play a key role in the CoC and be an important
- **CS has world-class expertise in many areas of computing**
- **Faculty in CS are capable and willing**
- **It has made significant impact, despite its small size**

Computer Sciences Impact

- **Founded in 1964, the CS department has remained small (about 34 faculty), but has made impacts on multiple fronts**
  - "On a campus famed for its breakthroughs in biotechnology, engineering, and agriculture, a much smaller department is exerting an outsized effect on the Wisconsin economy – and beyond", Tom Still, Wisconsin State Journal, 1/2/2016.

- **On entrepreneurship and jobs in Wisconsin**
  - **Alumni have founded numerous companies with thousands of jobs** in Wisconsin
    - E.g., Epic (~10,000), Nordic (200+), EatStreet (100+), etc.
  - **Have been involved in, and have fostered job creation on many fronts**
    - E.g., companies that we have founded or been involved with have been acquired for $340M, bringing investment dollars and connections to the state
  - Helped **attract R&D labs or large national companies to Madison**
    - E.g., Google, Microsoft,

Computer Sciences Impact

- **On big technology companies**
  - Alumni and faculty have had significant roles in Microsoft, Google, Facebook, and many others

Computer Sciences Impact

- **On powering education and research at UW-Madison and beyond**
  - We have **dramatically expanded our student population** in the past five years
    - Our undergraduate population has almost quadrupled in five years
    - The number of credit hours taught has doubled
  - We have **started two highly successful programs to serve working professionals**
  - We have **greatly expanded teaching of computing across the UW-Madison campus**, impacting thousands of students
  - Our effort to **push computing into K-12 curriculum** has been very successful and growing
  - Our effort to help **power research at UW-Madison** has been extraordinarily successful
    - Role in helping BMI department over the years.
    - Role of CHTC in accelerating the activity of many other domain scientists

Facilities

- **Building to accommodate CoC**

- **Enablers**
  - WARF
  - Alumni and other donors
  - State of Wisconsin

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