REQUEST FOR AUTHORIZATION TO IMPLEMENT A DOCTOR OF PHILOSOPHY IN COMPUTER SCIENCE AT UNIVERSITY OF WISCONSIN-MILWAUKEE PREPARED BY UW- MILWAUKEE

ABSTRACT

The University of Wisconsin (UW)-Milwaukee proposes to establish a Doctor of Philosophy (PhD) in Computer Science. The rationale for this program is that although Computer Science has offered a doctoral concentration in Computer Science within a PhD in Engineering for about 40 years, having a full major would increase visibility to outsiders, reduce the burden of collection of performance indicators, and allow greater flexibility in programmatic decisions specific to the discipline, which differs substantially from engineering. There are no anticipated changes in tuition structure for this degree program or in changes to courses. Students who complete the degree will be prepared for either Computer Research Scientists in industry or Instructors at post-secondary institutions that conduct both teaching and research. According to the Bureau of Labor Statistics (BLS), the demand for Computer Research Scientists is growing faster than average (about 23% over the next ten years)[1]. The demand for post-secondary instructors (across all areas) is growing at about 4% per year; however, the growth in demand for all computer occupations requiring a bachelor's in Computer Science is expected to grow 10% over the next decade, creating a greater need for post-secondary Computer Science instructors than for other areas. In this document, we include information about market demand and enrollment demand for PhD in Computer Science and Computer and Information Science doctoral graduates at the state, regional, and national levels, which all show growing unmet needs. Growth in PhD completions has been about 33% in the region over the past decade, but static in the state. By contrast, market data at the national level shows an unmet market demand of over 85%, and even if PhD graduates from all related areas were hired instead, the unmet need exceeds 15%.

PROGRAM IDENTIFICATION

University Name
University of Wisconsin-Milwaukee (UWM)

---

[1] U.S. Bureau of Labor Statistics "Occupational Outlook Handbook, Computer and Information Research Scientists" URL: https://www.bls.gov/ooh/computer-and-information-technology/computer-and-information-research-scientists.htm (Accessed December 2023).

Title of Proposed Academic Program
Doctor of Philosophy in Computer Science

Degree Designation(s)
Doctor of Philosophy

Proposed Classification of Instructional Program (CIP) Code
11.0701

Mode of Delivery
Single institution, taught as in-person instruction

Department or Functional Equivalent
Department of Electrical Engineering and Computer Science, Computer Science subgroup

College, School, or Functional Equivalent
College of Engineering & Applied Science

Proposed Date of Implementation
August 2024

PROGRAM INFORMATION

Overview of the Program

Computer science is the study of the theory, design, implementation, and performance of computer software and computer systems, including the study of computability and computation itself. Computer science has its origins as an applied subdiscipline of mathematics in the 1960's, but has developed its own formalisms for describing data and software methods that can be deployed on a growing variety of computing platforms. Careers in computing take on a variety of forms and now span every sector of the economy and every region of the world. A doctoral degree in computer science includes both breadth in core areas of computer science (assessed via a written qualifying exam), as well as advanced coursework and mentored research, culminating in an oral defense and written dissertation.

The minimum degree requirement is 66 graduate credits beyond the Bachelor's degree with minimum credit distribution as follows: 21 credits in the major area; 9 credits in an approved minor area; 6 credits in mathematics and/or quantitative methods; 9 credits of approved electives; 3 credit CEAS Graduate Seminar (Ethics and Engineering Communication); A minimum of 26 credits, excluding dissertation, must be at the 700 level

or higher; 18 credits of doctoral thesis. A minimum of 33 credits (including thesis) must be completed in the Ph.D. program at UWM.

A maximum of 33 credits may be considered for transfer from prior graduate work, including a Master's degree earned at UWM or elsewhere provided the course work taken falls within the appropriate areas and has earned a grade of "B" or better. Students are admitted based on GPA in a related BS or masters degree in Computer Science, and GRE scores. See https://catalog.uwm.edu/engineering-applied-science/engineering-applied-science/engineering-phd/#requirementstext.

Projected Enrollments and Graduates by Year Five
Table 1 represents enrollment and graduation projections for students entering the program over the next five years. This table shows a small amount of growth, comparable to what has been observed over the past five years.

Students/Year	Year 1	Year 2	Year 3	Year 4	Year 5
New Students	4	5	5	5	6
Continuing Students	18	19	21	22	23
Total Enrollment	22	24	26	27	29
Graduating Students	3	3	4	4	5

Tuition Structure
For students enrolled in the PhD in Computer Science program, normal UWM graduate tuition and fee rates will apply. The most recent rates are shown below.

# of Credits	Resident	Non-Resident	Minnesota w/ Reciprocity	Midwest Rate	Segregated Fees*
1	1,006.67	1,846.11	1,532.63	1,341.07	337.88
2	1,738.97	3,417.85	2,790.89	2,407.77	401.39
3	2,471.27	4,989.59	4,049.15	3,474.47	464.90
4	3,203.57	6,561.33	5,307.41	4,541.17	528.41
5	3,935.87	8,133.07	6,565.67	5,607.87	591.92
6	4,668.17	9,704.81	7,823.93	6,674.57	655.43
7	5,400.47	11,276.55	9,082.19	7,741.27	718.94
8+	6,132.77	12,848.29	10,340.45	8,807.97	782.45

Student Learning Outcomes and Program Objectives
1. Apply advanced knowledge of mathematics, science, and engineering to solve complex problems.

2. Use modern tools or techniques to solve complex problems, conduct research, and analyze and interpret data.
3. Demonstrate proficiency and competency in the area of specialization.
4. Identify, formulate, and solve complex problems with an original and/or significant contribution to the field.
5. Demonstrate a familiarity with research in a related or complementary discipline.
6. Use quantitative methods appropriate to the field of research.
7. Understand academic, professional and ethical responsibility.
8. Communicate effectively via technical writing and oral presentations.

METHODS OF ASSESSMENT OF OUTCOMES

i. Outcome (1) is assessed through achievement of the Ph.D. Qualifying Examination.

ii. Outcome (2) is assessed through the dissertation proposal hearing.

iii. Outcome (3) is assessed through the Qualifying Examination and achieving a grade of B or higher in program of study.

iv. Outcome (4) is assessed in the preliminary examination (identify and formulate), in the thesis (solve) and in any published results.

v. Outcome (5) is assessed through achieving required B or higher average in selected course work (9 minor credits) and in the preliminary examination.

vi. Outcome (6) is assessed in the program of study's inclusion of appropriate course work with a grade of B or higher.

vii. Outcome (7) is assessed in the required ethics and communication course(s) being developed with a grade of B or higher.

viii. Outcome (8) is assessed in the Dissertation Proposal hearing and the Dissertation Defense.

Program Requirements and Curriculum

The PhD in Computer Science includes a minimum of 66 graduate credits beyond the Bachelor's degree with minimum credit distribution as follows: 21 credits in the major area; 9 credits in an approved minor area; 6 credits in mathematics and/or courses designated as covering graduate-level quantitative methods; 9 credits of approved electives; 3 credit CEAS Graduate Seminar (Ethics and Engineering Communication); A minimum of 26 credits, excluding dissertation, must be at the 700 level or higher; 18 credits of doctoral thesis. A

minimum of 33 credits (including thesis) must be completed in the Ph.D. program at UWM. Table 2 summarizes these requirements.

Before completing 24 credits, students must pass a two-day written examination covering both foundations and at least one advanced topic area. Day 1 of the exam covers foundational coursework in computing hardware, software, and theory, specifically Computer Architecture, Operating Systems, Programming with Data Structures & Algorithms, Discrete Mathematics, and Algorithm Design & Analysis. Day 2 covers an advanced area of study, selected from one of the research strengths of the department, including Artificial Intelligence; Computer Graphics & Image Processing; Natural Language Processing & Text Retrieval, Programming Languages & Compilers; Theory & Algorithms.

Table 2: PhD in Computer Science Program Curriculum

| Academic degree program or major course requirements:	
Computer Science graduate-level courses	21 credit(s)
Approved minor area	9 credit(s)
Quantitative methods	6 credit(s)
Electives	9 credit(s)
CEAS Graduate Seminar (EAS 701, 702)	3 credit(s)
Dissertation	18 credit(s)
Total Credits	**66 credit(s)**

Collaborative Nature of the Program
This program does not include any formal collaborative agreements, however doctoral students in computer science are frequently supervised by affiliated faculty from other areas of engineering, physical sciences, or public health.

Projected Time to Degree
Students typically take 3 to 6 years to complete their degrees (11 terms, averaging 6 credits per term). Two years to complete preliminary coursework, before taking a qualifying exam, one year taking advanced coursework, and the rest doing doctoral research for the dissertation. Students may be granted advanced standing if they have a completed a masters in computer science, which has 31 credits, allowing them to finish the remainig work for the PhD in three years. This time is consistent with data collected by the National Science Foundation[2], shown below.

---

[2] NSF Data Tables, Survey of Earned Doctorates, URL: https://ncses.nsf.gov/pubs/nsf22300/data-tables (Accessed December 2023).

Figure 1. Median Years to Complete PhD in Computer Sciences

Source: NSF Survey of Earned Doctorates
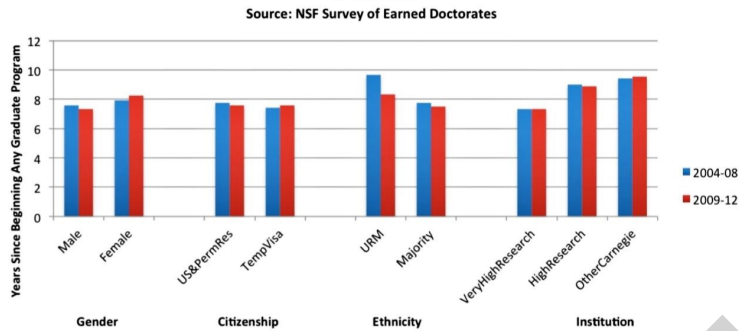
Accreditation

The program is accredited by the Higher Learning Commission (HLC) through normal campus-level processes. No specialty accreditation requirements are anticipated. No additional approvals will be required from HLC as It is not an online program.)

PROGRAM JUSTIFICATION

Rationale

UW Milwaukee (UWM) currently has a college-wide PhD program in Engineering with a concentration in Computer Science. The proposed program would split the computer science portion of that existing program, to become a PhD in Computer Science, but not otherwise change program requirements or fees. The rationale for the change is that creating a separate PhD major would improve program visibility, administration, and assessment. First, having a PhD degree that is, officially, in Engineering, rather than in Computer Science has at times caused the very existence of a PhD concentration in Computer Science to be in doubt, both when students look for degree programs and when ranking agencies assess programs. Historically the UWM computer science PhD has not been included in national rankings, such as those by US News and World Reports. We believe that a more specific degree name would end these doubts and aid in attracting top PhD student candidates to the program. Second, department faculty would like more autonomy in administering the program, including scheduling and evaluation of the PhD Qualifying Exam. Third, having a combined college-wide program has made it difficult to collect data on our (CS) students and graduates, as all PhD students in the college are, officially, in Engineering rather than Computer Science.

Computer Science is also a unique discipline from engineering, with origins outside of Engineering. Computer science is the study of the theory, design, implementation, and

performance of computer software and computer systems, including the study of computability and computation itself. Computer science has its origins as an applied subdiscipline of mathematics in the 1960's, but has developed its own formalisms for describing data and software methods that can be deployed on a growing variety of computing platforms. Careers in computing take on a variety of forms and now span every sector of the economy and every region of the world.

The undergraduate computer science program at UWM has been present in the College of Engineering since the college was founded – as part of a joint department of Electrical Engineering and Computer Science, that operates with two chairs and two distinct budgets. The undergraduate computer science program has the highest enrollment of the seven engineering programs at UWM (Biomedical, Civil, Computer Science, Electrical, Materials, Industrial, and Mechanical), and graduates approximately 100 students each year. The department plays a key role in the college's mission to educate students to become creative problem solvers, and to act as a catalyst for improved economic development and quality of life in Wisconsin. With the fast-paced changes in computing, the department is critical to the college and university to achieve the strategic goal of anticipating and responding to market demands in order to produce graduates who are prepared to address and adapt to the changing needs of the marketplace and society.

At the graduate level, currently there is a long-standing, college-wide PhD program, spanning the various engineering disciplines of the college. Each engineering discipline that is part of this program defines a concentration with major coursework and qualifying exam questions from that discipline; thus, each engineering discipline functions, essentially, as its own individual program. Two programs, Mechanical Engineering and Electrical Engineering, have already taken action to create their own programs, by splitting from the college-wide program. With this Notice of Intent, we similarly plan to separate the CS portion of the college-wide PhD program into its own program. The need for this action is detailed in the following section.

Institution and University of Wisconsin System Program Array

Alignment with Institutional Mission, Strategic Plan, and Existing Program Array The program, being focused on research and advanced education, clearly serves the broad UW–Milwaukee mission for discovery, research, and education, and supports the generation of new knowledge for the development and betterment of society. Related programs at UW-Milwaukee include the PhD in Engineering, PhD in Biomedical and Health Informatics, and

the Master of Computer Science (MS CS). Students in these other programs typically do not have a prior degree in Computer Science. Graduates with a MS CS sometimes elect to continue their development through a PhD at UWM.

Impact on UW-Madison's CS PhD Program: UW-Madison offers a PhD in Computer Sciences, which is the same area, but targeting a different student population, of mostly traditional students, many who work for faculty as research assistants. We do not expect that the UWM program will have any effect on the CS PhD program in Madison. Our student pool is largely drawn from two groups. One is information technology professionals working in industry in Milwaukee, who are self-supporting. They typically choose UWM because it is convenient, and for them, Madison is too far to commute. The creation of a stand-alone CS PhD program will not affect these students. The other main group is foreign students, but our program and the program at Madison have different admission criteria (which is the current situation, and which will not change in the proposed program). Most of these students will be supported as teaching assistants, with a few funded as research assistants. Most seek jobs in industry or at post secondary institutions that focus on teaching. (One PhD-level CS graduate from UW-Milwaukee have become Teaching Faculty at UW-Madison.) Thus, the proposed program will neither produce unnecessary duplication within the UW System, nor negatively impact the program at UW-Madison.

Need as Suggested by Student Demand
Our program primarily includes in person instruction and research, while serving graduate students that work full or part time in the Milwaukee area (place-bound), those that come to work with specific faculty on funded research, and those have a desire to be in the Milwaukee area, as well as foreign students, who appreciate the affordability of the area. The program hires 25 to 30 teaching assistants each term and it is possible for doctoral students to subsist on the stipends we offer. Enrollment in the Computer Science portion of the PhD has been 18 to 20 students (18, 20, 20, 20) each year for the past 4 years (2019-2022) and graduates about three students per year.

Need as Suggested by Market Demand
Market data has been collected at the State, Regional and National Level. State data collected via Lightcast (see WI PhD CompSci Program_Overview_6480.pdf) for 2021 on target occupations predicts 226 Annual Openings in Wisconsin, corresponding to a one-year increase for 2022-23 of 23%. The highest growth, and highest median wage, was for Computer and Information Research Scientists, with a median wage of $67.30/hr (about

$140K per year) and growth of 4.76%. One year job posting data shows about 200 unique employers and 820 unique postings. Top employers listing ads include pharmaceutical companies (Parexel and Pfizer) and Manufacturing (General Electric, Siemens, & Northrup Gruman). The number of openings is far below the number graduated PhD in Computer Science in Wisconsin. This data lists two institutions currently offering separate PhDs in Computer Science. (These institutions are UW-Madison and UW-Marquette; however UW-Madison uses the program name," PhD in Computer Sciences"). Together they graduated just 14 PhD students in 2021, all but one at UW-Madison (which uses CIP 11.101, while Marquette uses 11.701, as does UWM). The total completions was the same in 2012. Data from UWM is not included, because it has not offered a full major.

Regional data collected via Lightcast (see [Midwest Compsci PhD Program_Overview_1096.pdf)](#) for 2021, shows about 2800 regional openings versus 343 PhD in CS completions (meeting just 1/8th the advertised need), with a one-year growth of about 3%. Providing these graduates were 32 PhD CS granting institutions (but UWM CS was not included as our PhD is listed as Engineering). Regionally, the greatest growth has been for Information security analysts (4.39%), but the highest median salaries went to Computer and Information managers. Overall, 74% of the PhD CS completions (255 of 343) were at public universities, such as UWM and UW-Madison. The largest of these programs was University of Illinois Urbana-Champaign, which had 52 completions. Regionally, the ten-year growth in completions for non-distance PhD in Computer Science has been about 33%, far from saturating the need.

National data collected via Lightcast (see [US Compsci Program_Overview_6724.pdf)](#) for 2021 shows about 17,800 openings versus about 2000 PhD CS completions, with a one-year growth rate of about 4%. The largest number of openings was for Software Developers (about 71,000, with 5.1% annual growth, second only to Information Security which had 5.25% growth). Occupations with highest salaries were Computer and Information managers (with median pay about $160K per year), followed by Computer and Information research scientists (median pay about $134K per year). Providing PhD CS graduates were 169 institutions. The unmet need may be as high as 15,000. If all general Engineering and computer Engineering graduates were included, that would add 1000 PhD completions, leaving 75% unfilled, and even if PhD graduates from all related areas were hired, the unmet need exceeds 15%.