

## **Strategic Plan for Computer Science & Engineering at the University of Washington**

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### **Department Overview**

UW Computer Science & Engineering is a national leader in research and education. Ranked among the top 10 programs in the country, CSE has produced world-class leaders in both academia and industry. We collaborate broadly with other programs at the university and with key technical organizations (such as C&C). CSE faculty and former students have created over a dozen companies and transferred many additional technologies to existing companies. We are a major supplier of students at both the bachelors and graduate levels to Microsoft, Amazon.com, Google (which is growing rapidly in Kirkland), and others. And our technologies have impacted the public at large. For example, we were an early leader in Web search technology (WebCrawler, Metacrawler, and a startup that introduced the first comparison-shopping agent); we invented “hyper-threading,” which improves the performance of Intel’s Pentium-4 processors; and our animation technology impacts movies and games created by companies such as Pixar and EA Sports. Impinj, Chris Diorio’s recent CSE spinoff, is currently the leading supplier of RFID technology and is guiding the world standards effort in RFID.

CSE currently has approximately 40 faculty (a modest size on the national level). We have 450 undergraduates in our computer science and computer engineering bachelors programs, producing around 160 graduates per year. We have 125 masters students in our evening professional masters program, created 10 years ago to help local companies recruit, retain, and advance their employees. And we have 150 students in our full-time graduate program.

### **Strengths**

- CSE’s most important strength is its culture, which is based on a highly collegial, non-hierarchical structure. Collaboration is highly valued. This is even reflected physically by our building layout, in which faculty and student offices are arranged to maximize interaction and mixing across disciplines and age groups. We are externally competitive, but internally non-competitive. Overall, we act as a coherent unit where individuals support each other and act for the good of the department as a whole. Our students and staff share our culture and are a valued part of the department.
- We value quality of life and help our students to be well rounded as people. We take mentoring seriously and have formal procedures for mentoring students, faculty, and staff.
- We are leaders in research (nationally and internationally influential, and regarded among the top half dozen programs) in operating systems, networks, Internet systems, ubiquitous

computing, programming systems, artificial intelligence, graphics, vision, and other areas.

- We produce students of the highest quality. Our Ph.D. students have received offers from all of the best schools. In several recent years we produced the most sought after Ph.D. student in the country. In 2003, ACM's Best Grad Student Research Award went to our PhD student, Mike Swift, and the ACM Best Dissertation Award went to our PhD graduate, AnHai Doan.
- Our senior-level computer animation sequence, which unites students in computer science, music, and art, and trains them in all aspects of animation, is unique on a national level.
- We support technology transfer. CSE has been the source of over a dozen startups and a number of important technologies licensed to industry.
- We are recognized throughout UW and the region as an excellent program and an excellent partner.
- We have strong connections to the northwest technical community and to our alumni, and we have an excellent record in development.
- We benefit from a strong (and growing) research community in Seattle, with hundreds of high-quality researchers at Microsoft Research, Intel Seattle Research, Google, Adobe, etc., many of whom are closely affiliated with CSE.
- We have arguably the best designed CSE building in the country.

## Weaknesses

- We have a presence at the biology/computing interface, e.g., two faculty in computational biology, one in neuroscience, a new faculty member in robotic neuroscience, and interactions in medical imaging, medical informatics, and biology. However, given the strengths of UW across medicine, genetics, and biology, we have not found a way to benefit at the level we should to become a leader in this area.
- In general, while we are among the top half dozen programs in a number of areas of the field, we are not among the top one or two in any area. While "breadth with strength" is of tremendous value, we also need to identify several important areas in which we will strive to be *the* leader.
- In the spectrum from CS to CE, we are known more for CS than CE. We need to take steps to better develop our strengths in CE.
- We are losing Henry Kautz, a top researcher in artificial intelligence (AI), who has also been working in "assisted cognition" to help people with cognitive disorders such as Alzheimer's. This is a big loss in both core AI and our efforts on helping people with disabilities. We are highly likely to lose Alon Halevy, a top researcher in AI and data management, whose startup was acquired by Google. These twin departures leave us vulnerable in several important fields.

## Opportunities

- **Biology and Health Sciences:** Given Washington's huge advantage with institutions such as FHCRC, UW Medicine, the departments of bioengineering, biology and genome sciences, and private institutions such as the Institute for Systems Biology and the Allen Institute for Brain Science, UW can take a leadership role in new technologies combining health sciences and computing. CSE can play a significant role by growing crucial expertise in areas such as computational biology, computational neuroscience, neural engineering, medical image analysis, medical robotics, and medical informatics. Recruiting Yoky Matsuoka this year is a huge step in this direction and opens a number of collaborative opportunities. With Yoky, Raj Rao, and others in CSE, we need to partner with people like Lee Hood (ISB), Tom Daniel (biology), David Baker (biochemistry), and Maynard Olson, William Noble, and Phil Green (genome sciences), to map a winning future on the borders of Bio and CSE.
- **Non-Traditional Models of Computing:** Current semiconductor technologies have run into a wall. In the long run, quantum computing, nanotechnology, biologically inspired computing, and highly-parallel (e.g., dataflow) computing concepts will have impact. In hiring David Bacon (a physicist well known in quantum computing) as Research Faculty, who works with Professor Mark Oskin (dataflow and quantum), we made our first steps. We have worked hard to help attract Gabriel Aeppli; if he comes to UW we will have an opportunity to build a solid base in nano / quantum areas, with Aeppli helping to attract high-caliber people on the CSE side of the nanotech center. This could have enormous impact to UW and the state.
- **Data Mining and Machine Learning:** New computing and sensor technologies enable all of the sciences to instrument and collect huge amounts of data from the natural world. Extracting knowledge and insight from this huge volume of data, however, creates enormous challenges – challenges that computer scientists can tackle. We have several faculty in this area, e.g., Pedro Domingos, Dan Weld, and Oren Etzioni (whose new startup, Farecast, uses machine learning to predict airfare trends). We could partner with people like Marina Meila and Werner Stuetzle in statistics, and with others on campus, to become leaders in data mining, machine learning, databases, and scientific visualization and animation – disciplines helping scientists to organize and recognize important patterns in vast data fields.
- **Computer Security:** Computers and networks are a part of everyday life, yet most computers and networks were designed for a safer world than exists today. Leveraging local strengths across campus (e.g., medical school, C&C, EE, iSchool, and the new *Center for Information Assurance and Cyber Security*), current faculty Steve Gribble, Tom Anderson, Hank Levy, and recent hire Yoshi Kohno, UW can become a national leader in computer security. We are off to a strong start with our several roles on the NSF GENI Initiative, which envisions a more reliable, more secure, and more scalable next-generation Internet. UW Educational Outreach is being considered by the DHS to create a National Homeland Security University program, and computer security would be an important component.
- **Human-Computer Interaction (HCI):** Computers now rank among the most stress-producing devices. The average citizen is faced with myriad computing devices that are

nearly unusable and unmanageable, leading to enormous frustration and expense. The field of HCI develops new technologies and models for simple and intuitive interaction with technology. It combines computer science and engineering, social science, and psychology. Hiring James Fogarty this year, who will join James Landay and Alan Borning in CSE, along with the hiring of Jake Wobbrock by the iSchool, puts UW solidly on the road map in this area. Other departments, from technical communication to urban planning, have expertise as well. With this core, there is significant opportunity to grow UW into a national leader in HCI.

## **Threats**

- Funding opportunities at the national level are increasingly competitive. The acceptance rate in many NSF programs is now below 10%. Some sub-areas have been nearly wiped out.
- Our state political environment often does not value a research university and does not support research at the level of some other states.
- Our salaries significantly lag peer departments at the full professor level. Our mean salary for full professors is over \$16K below the mean for departments ranked 1 – 12, and over \$23K below the mean for departments ranked 13 – 24. We are ripe for picking from both universities and industry.
- While industry salaries have always been high, the advance of Google and its competition with Microsoft and others has dramatically increased the disparity. Both companies are focused on hiring the best and the brightest and can offer significant incentives (literally millions of dollars). We have lost two faculty to Google recently and may lose more to industrial offers in the future. Microsoft salaries for top researchers are double ours. While we cannot expect to compete with such companies, lagging significantly behind peer departments makes industrial offers even more attractive.

## **Goals**

CSE can become one of a handful of top programs setting the national agenda in computer science research, education, and impact. At the same time, we wish to elevate our computer engineering program to the same national level as our computer science program. We want to produce graduates that become true national leaders in both academics and industry. Our programs should help to stimulate the intellectual life and economy of the region.

To achieve these goals we will carry out a well-defined strategy, partnering with other units in the college and across the university, as well as with our academic and industrial partners outside of the University of Washington.

## Strategy

We have built a top-ten program on our core strengths in computer science and engineering. We have always partnered with other departments as well, and our value as a partner is based on our core strengths. Maintaining those strengths is therefore crucial to us. In the future, though, we will be increasingly proactive about seeking and creating opportunities to partner with departments inside and outside of the college. We will look to new application areas that have high leverage both to CSE and others.

Among a large number of possible initiatives, we believe the following have the highest potential for major impact over the next several years and can maximally leverage the opportunities listed previously. We have divided these into three categories: research, education, and outreach.

### *Research*

1. *Neural Engineering.* There is exciting work at the interface of neuroscience and engineering, and UW is poised to be a leader. We will investigate a new center for neural engineering including faculty from CSE (Raj Rao and Yoky Matsuoka), EE, bioengineering, biology, physiology, neurobiology, and the medical school. Collaborative work across these departments has already occurred, but several new faculty and/or staff positions will be needed to solidify a central focus. There are significant funding opportunities in neural engineering from NIH (Bioengineering Research Partnerships – BRP) and DARPA (Human Augmentation Programs). Technically, we need a replacement for Chris Diorio who worked on the hardware side on both implantable computers and neurally inspired computers (Chris left to work full time at his startup). Only modest facilities growth will be required.
2. *Human-Centered Computing.* There is enormous potential in research that impacts people directly. One possibility is to leverage the several efforts across campus that use computing technology to help the disabled, including the campus wide DO-IT program (Sheryl Burgstahler), Richard Ladner's Tactile Graphics and WebInSight projects in CSE, Yoky Matsuoka's neurobotics effort in CSE, Raj Rao's studies in biomedical applications for the disabled, efforts in the iSchool, in neurobiology, various efforts in the medical school, etc. This summer, Richard Ladner (recipient of a recent *Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring*) is leading a Mentoring Workshop for the Blind in Science, Technology, Engineering, and Mathematics in the Allen Center. Gaining national recognition in this area will require a campus center to bring together those involved in computing for the disabled, as well as a new faculty leader to run the center. In the area of human-computer interaction, James Landay (CSE) is creating an alliance of faculty and students across campus, called DuB. Currently affiliated departments are CSE, Technical Communication, the iSchool, Biomedical Informatics, Urban Planning, Digital Arts, and Art. There are two strong new hires from the CMU HCI Institute: James Fogarty (CSE) and Jake Wobbrock (iSchool), who is also adjunct in CSE. Yoky Matsuoka could be considered part HCI as well, along with others in CSE (e.g., Alan Borning, Dan Weld, Richard Anderson). Future systems will adapt research in machine learning, adaptive interfaces, and computer vision to provide high levels of understanding of human contexts and gestures; we have expertise to be on the leading edge of such advances..

3. *Computer Security.* The UW has some strength in the existing *Center for Information Assurance and Cybersecurity*, an educational center approved by the National Security Agency and run through the iSchool. Participants in a research-oriented effort could include CSE, EE, the iSchool, Business, Law, Urban Planning, C&C, and UW's CISO. A recent (very promising) visit by the NSA focused on the creation of UW as center of research expertise, based on current efforts and talent in CSE and EE. Our hiring of Yoshi Kohno, who bridges the space from crypto to applied security, will put us solidly in the field. However, people like Yoshi are being produced only one every 5+ years. A second (possibly more senior) hire is needed to give depth to a center in security that UW requires to put us in a national leadership position. This hire would likely be core CS/security but could easily have ties to EE and the iSchool. As well, future hires in other core areas could be focused on security (e.g., software engineering or languages applied to security). The CIAC needs solid technical leadership and must be moved from education-only to a research center in order to attract significant funding from the security community. Possible funding sources include NSA, the new ARDA National Intelligence Community Enterprise Cyber Assurance Program run by Carl Landwehr (formerly of NSF Cybertrust), NSF Cybertrust, and GENI (in the future).
4. *E-Science.* Several years ago, CSE and Statistics tried to create a joint data mining center supported by WRF. It failed because the director being recruited could not relocate (another attempt at him last year failed as well). Since that time, the importance of machine learning across science and engineering has increased enormously. We believe that there is an opportunity to create a broad cross-campus effort in data mining and machine learning. This could be part of a more wide-ranging e-science initiative for the campus that includes other computing fields of interest to science and engineering, e.g., scientific visualization and sensor networks. One strong potential hire might be Carlos Guestrin – now an Assistant Professor at CMU. He interviewed here last year but has a two-body problem (his fiancé, a 2004 PhD in Biophysics from Stanford and now postdoc at LBL, is still establishing her career, and while she visited UW, she didn't really apply). Carlos could easily collaborate with people in mechanical engineering, environmental engineering, oceanography (Project Neptune), etc.
5. *Strengthening Computer Engineering.* In terms of research, there are areas of computer engineering where we have a lot of strength: computer architecture, reconfigurable hardware, location-based computing (joint with Intel Research Seattle), and the systems aspects of sensor networks (e.g., RFID). But we need to expand our strengths. Our strategy is to avoid segmenting our computer engineering efforts from our computer science efforts; rather, to be certain to include the forward-looking aspects of computer engineering in the various initiatives that we undertake. We see three principal forward-looking challenges in computer engineering: new computation technologies (e.g., quantum computing), designing for statistically highly-variable components, and low-power sensing and actuation systems. We are well positioned in quantum computing with Oskin and Bacon and possibly Aepli. Learning to design in the face of highly varying manufacturing specifications will require new theoretical foundations that should be of interest to our theory and machine learning groups; however, this may require an opportunistic new hire whose primary focus is in this area and will have the connections to EE (who should have the expertise in understanding the manufacturing models). We will need to rely on EE, MechE, ChemE, and BioE for new

sensing and actuation devices and on EE for low-power radio communication. CSE brings strengths in building *systems* of devices with particular emphasis on networking and distributed computation. Sensor networks and neurobotics are examples in this area. Yoky Matsuoka represents the kind of hiring we need to do - someone who puts devices to work in an interesting ensemble. Opportunities exist from medicine (Borriello is investigating with wearable sensing for personal health) to oceanography (Neptune's distributed sensing systems).

### *Education*

1. *Create a new 5-year combined BS/MS program in CSE.* We will expand our undergraduate program to allow some of our best bachelors students to spend one more year in the program to obtain a MS in Computer Science & Engineering. An MS is an extremely cost-effective degree in terms of the increase in technical knowledge and ability, relative to the short additional time spent in the program. It also enables students to enter the workforce at a higher responsibility and salary level, and to advance more rapidly. We have already sent a proposal for this program to people seeking to support high-demand enrollments.
2. *Create a 5<sup>th</sup> year Masters in Animation/Digital Arts.* Computer animation is a unique aspect of our undergraduate program. Working together with students in music and art, computer science students produce impressive animated films over several (sleepless) quarters. We will create a new, 5<sup>th</sup>-year masters program in animation and digital arts that would feed the growing demand for animators in the movie, advertising, and game industries. It would be a special branch of our 5-year combined BS/MS degree, primarily for students who have taken our senior animation electives as part of their BS.
3. *Increase the Ph.D. Program.* Over the last decade and more, we have ramped up our undergraduate programs in both computer science and computer engineering to the point where we are unbalanced towards the undergraduate side, at a time when advanced degrees are in high demand. In addition to the bachelors/masters program just described, we must increase the size of our “traditional” research-oriented M.S./Ph.D. program. This is part of our high-demand enrollment request as well.
4. *Create a New Minor in “E-science.”* Aspects of computer science are increasingly essential to all fields of science, engineering, and beyond. We propose to introduce six undergraduate and graduate service courses on topics such as machine learning, data mining, databases, and scientific visualization. They will constitute a minor in “e-science” which should be of broad interest to undergraduate and graduate students from across the university. This is also part of our high-demand enrollment initiative.

### *Outreach*

1. *Technology Transfer.* We will enlarge interactions with industry, local and national, through our existing Industrial Affiliates Program (which currently includes over 60 companies), through our personal and professional ties with industrial researchers, and through our former students who now work in a large set of high-tech companies. We will also create an

industrial advisory board to help us get input and direction from some of our industrial partners.

2. *K-12 Communication.* We will help expand regional awareness of the intellectual opportunities in CSE through renewed outreach to K-12 students and teachers. Our goal will be to increase student interest in the computing disciplines, particularly among top students from under-represented groups (e.g., women). Our new diversity-oriented student recruiting videos, and plans for their active use over the next year, are a key example. Our focus on diversity arises from enlightened self-interest: if computer systems are to be used by all elements of the population, then all elements of the population must help design these systems. We understand the challenges of working with K-12. We have many assets, though. Lazowska has received awards from UW, the Seattle Schools, and national organizations for his K-12 activities. Each year for many years, we have collected the names of “influential high school teachers” from our new majors. There are programs that have been prototyped nationally (e.g., by CMU) that can be translated to the Washington State context. Our objective is not to “change K-12” – rather, our objective is to raise the profile of computer science as a possible major and career. Our goal is to take our existing efforts, focus them, and take them up a level in impact. We are actively seeking development opportunities related to this.
3. *Community Outreach.* We also will continue to work to increase regional public and political awareness of the sorts of educational opportunities needed to participate in our state’s “new economy.” We consider CSE to be the “poster child” for bachelors and advanced education as preparation for the world of tomorrow. Our focus on public awareness arises from a desire to increase public support for the University of Washington, and also to elevate aspirations and opportunities for children who grow up in our region. We have close ties to organizations such as the Technology Alliance and the Puget Sound Regional Council, as well as to the regional affairs groups within companies such as Microsoft, through which we do this work. In addition, as a highly successful program for many years, our alumni are our greatest source of ties to industry. We will build these bridges even more strongly in the coming years, with the goal of continually increasing the relevance of our programs, the opportunities for our graduates, and our alumni support. In terms of metrics, engagement with our industrial affiliates program and annual fund contributions are important. We have just changed our staffing in the outreach area, and we will re-hire a development person as soon as personnel issues related to our previous unfortunate hire settle.