Department of Computer Science & Engineering
University of Washington

Self-Study
In Connection with the Ten-Year Review of the Department

January 2011

Members of the Review Committee:

Daniel T. Schwartz (Committee Chair)
Chairman and Boeing-Sutter Professor
Department of Chemical Engineering
University of Washington

E. Virginia Armbrust
Professor
School of Oceanography
University of Washington

John V. Guttag
Dugald C. Jackson Professor (and former Chair)
Department of Electrical Engineering and Computer Science
Massachusetts Institute of Technology

Jeannette M. Wing
President's Professor and Department Head
Computer Science Department
Carnegie Mellon University

Eric Horvitz
Distinguished Scientist
Microsoft Research
Microsoft Corporation

PART A: Background Information

Section 1: Overview of Department and Organization

A: Mission of the department

We seek to be national leaders in research and education and to have scientific, commercial, and societal impact through our research programs, our educational programs, and our outreach activities. We wish to educate our students so that they will reach their full potential in computer science and engineering research and industrial practice through a deep understanding of the fundamentals of the field, their application in solving important problems and creating products, and with an affinity for lifelong educational renewal.

B. Culture of the department

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.

C. Role in the university

The field of computer science & engineering is transforming all aspects of our lives: commerce, education, employment, health care, manufacturing, government, national security, communications, entertainment, science, and engineering. The field is also driving our nation's economy – both directly (the IT sector itself) and indirectly (all other sectors that are "powered" by advances in IT, including the Web).

Twenty years ago there were no portable telephones, video games, GPS devices, digital music players, or social networking applications. Today there are huge numbers of computers in every car, every plane, every house; we even carry multiple CPUs in our pockets. We have become totally dependent on ubiquitous networking connectivity for communications, information, and entertainment. Personal computers and laptops are rapidly ceding to a world that is transformed by high-speed networks, mobile computing, and the enormous data centers that create the cloud. In the scientific world of past decades, physical experimentation and mathematical analysis were the two fundamental paradigms in science and engineering. Today, sensor-based measurement, computer-based simulation, and automated data analysis and visualization have assumed a crucial and perhaps dominant role in scientific discovery.

We see ourselves as being central to the university of the future. The next decade also will see increasing, and increasingly deep, *intellectual partnerships* between computer science & engineering and other disciplines – from architecture to zoology, with art and astronomy and biology and business

and engineering and law and medicine and global health and music and many others in between. The result will be a transformation of these disciplines, and a transformation of computer science & engineering as well. For this reason, over the last several years, we have specifically moved to become more outreaching, more interdisciplinary, and more collaborative at the university level. This includes university-wide efforts such as DUB, started by James Landay in our department: DUB is a UW-wide HCI initiative involving CSE, the iSchool, the School of Design, and the Human-Centered Design and Engineering department – that has placed UW near the very top of the HCI landscape. In formation in CSE is a center-scale initiative created by Yoky Matsuoka in Neural Engineering that includes Biology, Neurology, Surgery, Electrical Engineering, BioEngineering, and others. It includes multiple interdisciplinary hires, including Yoky Matsuoka (robotics, neural engineering, mechanical engineering, bio engineering), Emo Todorov (joint with Applied Math who works on biomechanical modelling and control), Su-In Lee (joint with Genome Sciences in the UW Medical School who works on computational biology), Georg Seelig (joint with EE and adjunct in BioE, who works on Synthetic Biology), and others.

D. History of the department

The University of Washington's Department of Computer Science & Engineering began as an inter-college graduate program in 1967. Jerre Noe was hired from SRI as Chair; he was succeeded in turn by Bob Ritchie, Paul Young, Jean-Loup Baer, Ed Lazowska, David Notkin, and Hank Levy (who will serve a 7-year term, expiring in September 2013). In 1975 a Bachelor's program in Computer Science was initiated, targeted to graduate 40 students per year. Departmental status was conferred, and shortly thereafter the department was placed under the College of Arts & Sciences, where it thrived under the stewardship of Dean Ernest M. Henley. Eight years later, in 1983, we initiated an expansion of the Bachelors program to 80 graduates per year; during this interval the graduate program became steadily more full-time- and Ph.D.-oriented, and reached a size of roughly 125 students. In 1989 the department moved to the College of Engineering, changed its name to the Department of Computer Science & Engineering, and initiated a second Bachelors program -- an ABET-accredited Computer Engineering program targeted to graduate 40 students per year. In 1996 we started an evening Professional Master's Program (PMP) targeted to enroll 120 part-time students from local industry. In 1999 the department expanded its Bachelors program in Computer Engineering to 80 graduates per year (160 total Bachelors graduates per year, equally divided between Computer Science and Computer Engineering). In 2008, the Provost agreed to fund a "test drive" of a combined 5-year BS/MS degree at 10 graduates/year (we had requested 40/year); in light of the budget situation this was never fully funded, but we have over 20 students enrolled in that program (we look at this as a two-year program covering their senior year and 5th year). Enrollment in our two freshman-level programming courses has grown to more than 2,600 per year in the past decade.

E. Organization of the department

The department leadership consists of the Chair (Hank Levy), two Associate Chairs (Gaetano Borriello, who focuses on educational activities, and Ed Lazowska, who focuses on development and external relations), and an Executive Committee consisting of these three individuals plus four elected members (due to a voting tie we have five elected members this year -- Brian Curless, Yoshi Kohno, James Lee, David Notkin, and David Wetherall).

The Chair is appointed by the Dean for a five-year term; Levy was appointed in 2006 and recently agreed to a two-year extension, which ends in September 2013. The Associate Chairs are appointed by the Chair for short terms (one or more years) and for duties that correspond with current departmental needs and individual interests. Additional members of the Executive Committee are elected for one-year terms with a one-year reprieve after two consecutive terms.

The general duties of the Executive Committee are to be "in the loop" on all issues, to deal with straightforward issues without engaging the department as a whole, to approve simple appointments (e.g., Affiliate Faculty and postdocs), to ensure that the department as a whole is engaged on important issues, and to serve as a two-way communication channel.

The department has about 42 tenure-line faculty members, 4 research-track faculty members, 5 instructors, and around 20 postdocs. We have has roughly 20 administrative staff, 15 technical staff members, and 5 educational advisors. The staff is divided into four "clusters" (organization charts are included as Appendix A):

- Technical Support (largely centralized, rather than associated with specific faculty or groups)
- Academic Advising (for the Bachelors, Professional Masters, and Full-Time Graduate programs)
- Central Administrative Support (the Business Office, the Assistant to the Chair, the Receptionist, the External Relations Coordinator, and a Facilities Manager)
- Faculty Support (administrative staff providing direct support to clusters of faculty members)

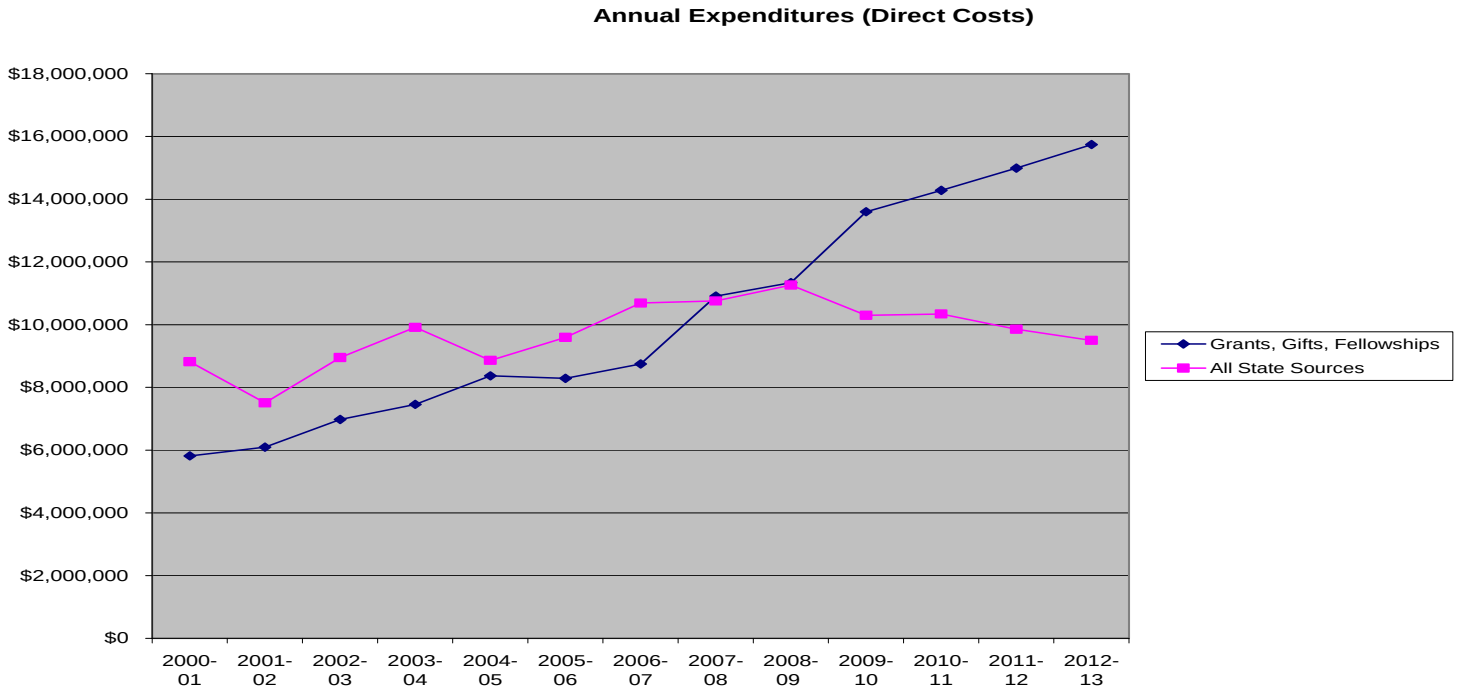
We formed our first external advisory committee in 1999, but the committee had not met in many years. In 2008 we formed a new committee consisting of Barbara Liskov (chair), Randy Bryant, Deborah Estrin, Tom Mitchel, Christos Papadimitriou, Pat Hanrahan, Eric Horvitz, and Jeff Dean; the committee met in January 2009. We did not reconvene the committee in 2010, since we were anticipating this 10-year review.

F. Budget and funding

The department has two major sources of funding: Washington State funds and research grants. In addition, we have income from gifts, endowments (professorships, scholarships, and fellowships), and from our Professional Master's Program (PMP). The figure below shows *expenditures* from state sources and from grant, gift, and fellowship sources over the last decade. Over that period our expenditures from grants have increased from just under $6M to nearly $14M. Of course, grants approved are ahead of expenditures; we received around $17M in grants and gifts in 2009/2010, as well as $3.3M in grant cost returns, PMP income, endowments, etc.

On the other hand, a significant UW budget cut will reduce our state funding, which reached a maximum of nearly $11M in 2008, down to its 2002 level of under $9M. This cut has meant the loss of 7 future faculty positions, 5 staff members, a number of TAs, and various department services. Before the budget crisis we had received state funds to grow to 50 tenure-track faculty members in return for program increases at both the undergraduate and graduate levels. At this point any student growth is on hold and faculty growth must be funded primarily from retirements, or we will have to bridge from savings for future positions that may or may not materialize. The move to a new

university-wide budget system ("activity-based budgeting") creates further uncertainties, making it difficult or impossible to project our budget looking several years into the future, although at the moment the new budget system has been delayed for a year.



G. Space

Prior to 2003 we were housed in Sieg Hall ("the ugliest building on campus"), where we had a total of 40,000 ASF of space. In Sieg we had no amenities (e.g., we had only one real conference room that also doubled as a lab). We had only 2 "real" research labs for the entire department. In 2003 we moved into the new Paul G. Allen Center, which provides approximately 75,000 ASF; we still control one floor of Sieg Hall (around 8K ASF, but not all usable), which we use to teach our computer animation capstone sequence and for various other purposes (special offices, housing special equipment, server rooms, etc.). In the Allen Center we have numerous instructional and research labs, high-quality amenities, office space, etc. This has allowed us to expand our research in several ways, e.g., to become more experimental and to add new kinds of research staff (we now have approximately 20 postdocs, compared to one or two postdocs in Sieg, due to lack of offices at that time).

Over the seven years in the Allen Center we have grown significantly and are now filled to capacity both for office and research lab space. If we consider the space per research faculty member (42 tenure-track plus 3 research-track), we have around 1667 ASF per faculty member in the Allen Center (1785 considering TT only). Our late 1990s survey showed that our peer departments had around 2400 ASF per FTE at that time – over a decade ago. Our remaining space in Sieg is a problem from multiple points of view. First and foremost, making this space usable requires significant investment in remodeling dollars, yet the building is of terrible quality and at some point the university will (or

should) tear it down for a new project. Second, the university counts that space against us – complaining that we're not making good use of it, while refusing to invest in its upgrading.

Two years ago we did a feasibility study for the construction of a new building that would provide around 40K ASF of additional space, to be located directly across Stevens Way from the Allen Center. The estimate at the time was that such a building would cost around $70M and would have to be privately funded. Given the financial situation, we have not sought to raise funds for a new building at this time. We believe that any new construction would best be used for highly interdisciplinary and larger-scale projects, such as Yoky's neural engineering efforts, the DUB HCI research projects, vision/graphics, games, etc. We would also want to relocate all of our Sieg operations to the new building and to construct a high-quality lecture hall for department-wide colloquia, which are currently held in a miserable space in the EE building.

In summary, we have outstanding space in the Allen Center, however that space is now fully utilized. The Sieg Hall space is problematic – we do not have surge space to replace the 8K sq ft in Sieg if we needed to abandon the building. And we are forced to spend money to keep that poor-quality space in working order. We believe that space will become a significant issue for us in the near future if we continue to grow our research and teaching efforts, even in the absence of state funds.

H: Faculty hiring

Faculty hiring is one of the crucial ways in which we define our future. Over the past decade we have made significant choices to hire at both the junior and senior level. In the last 5 years or so we have specifically attempted to broaden ourselves and to hire more interdisciplinary researchers, while strengthening the core as well. We have hired the following 14 tenure-track faculty over that period:

Name	Hire Date	Level	PhD	Research Area	Prior Position or Postdoc	Joint Department
Joshua Smith	2010	Associate	MIT (Media Lab)	Sensors, robotics	Intel Research Seattle	EE
Su-In Lee	2009	Assistant	Stanford	Comp. bio, ML	CMU postdoc	Genome Sci.
Anup Rao	2009	Assistant	Texas, Austin	Theory	IAS & Princeton postdocs	
Luke Zettlemoyer	2009	Assistant	MIT	AI, ML, NLP	Edinburgh postdoc	
Mike Ernst	2008	Associate	UW	Soft. Eng., PL	MIT Assoc. Prof.	
Emo Todorov	2008	Associate	MIT (Cog. Sci)	Biomechanical control	UCSD Assoc. Prof. (Cog Sci)	Appl. Math
Shwetak Patel	2008	Assistant	Georgia Tech	HCI, ubicomp, sensors		EE
Georg Seelig	2008	Assistant	Geneva (Physics)	Synthetic Biology	Caltech postdoc	EE
Luis Ceze	2007	Assistant	Illinois	Architecture		
Yoky Matsuoka	2006	Associate	MIT	Robotics/neuroscience	CMU Assist. Prof.	
Yoshi Kohno	2006	Assistant	UCSD	Security/crypto		
James Fogarty	2006	Assistant	CMU	HCI		
Magda Balazinska	2005	Assistant	MIT	Databases/distr. sys.		
James Lee	2005	Assistant	Berkeley	Theory	IAS postdoc	

As an indication of the quality of these hires, this group includes 7 NSF Career Awards, 5 Sloan Fellows, 2 Technology Review TR-35 recipients, 2 Microsoft New Faculty Fellows, a MacArthur Fellow, a Burroughs Wellcome Career Award at the Scientific Interface, a host of best paper awards,

and many other recognitions. We work hard to mentor and support junior faculty (16 Sloan Fellowships in the department is just one indication).

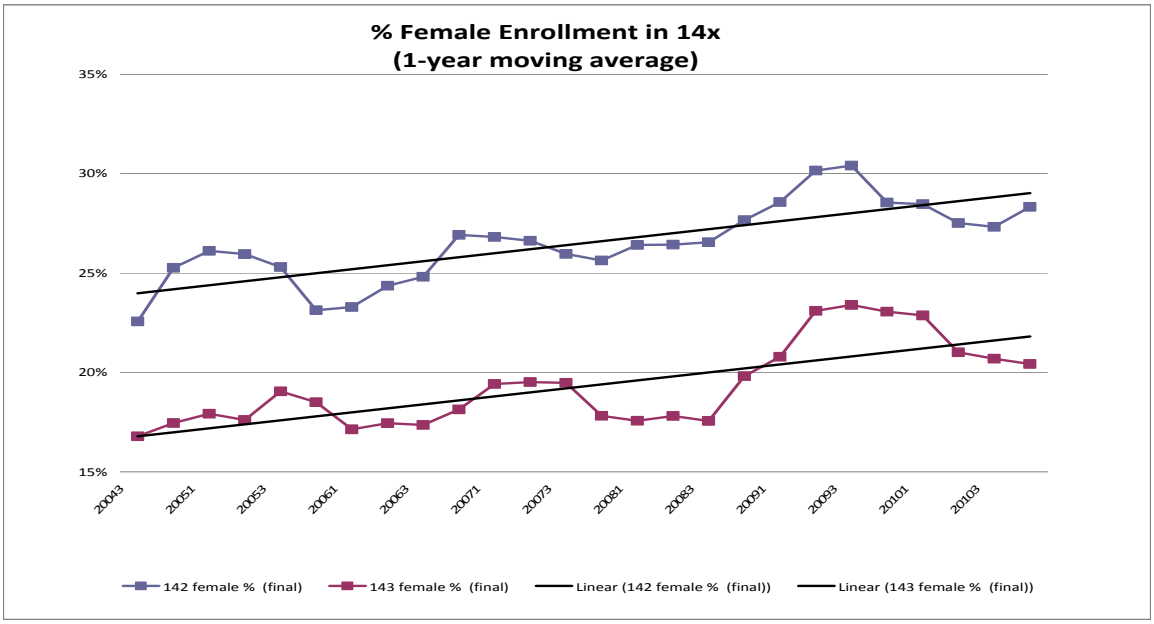
Over that same 5-year period we had a number of losses as well – all at the senior level. Alon Halevy, Craig Chambers, and Brian Bershad, all Full Professors, left for Google. Halevy's startup was acquired and he moved to Mountain View; Chambers decided he wanted to be in industrial development; and Bershad was recruited as Director of the new Google Seattle facility. Google has continued to be very aggressive in trying to hire our senior faculty: this year Steve Seitz and Yoky Matsuoka are on leave at Google, but we expect (or hope) that both will return. Henry Kautz left for the University of Rochester for family reasons (care for elderly parents). Chris Diorio (Associate Prof.) founded a startup that is the leader in RFID (Impinj) and is still there 6 years later. Venkat Guruswami (Associate Prof.), an extremely strong young theory researcher, was recruited by CMU.

These losses were significant, but we have hired exceptional young people in similar or adjacent areas (e.g., Rao in theory, Ernst in PL and SE, Zettlemoyer in AI/ML, and Patel and Smith in computer engineering). We are looking to hire in systems but have been very picky in this area.

I. Diversity

We take diversity seriously and have worked hard to try to increase diversity in the department, particularly the number of women students. We do a number of outreach activities. As examples, each year we hold a dinner for the "most influential high school teachers" as selected by our undergraduates, which is an opportunity to educate the teachers about our department and the opportunities that a CSE education presents for all students. In the summer we host a two-day CS4HS (Computer Science for High School Teachers) workshop to educate HS math and science teachers about fundamental concepts in computing and their importance. Under Richard Ladner, we have significant activities for disabled students, particularly those who are deaf or hard of hearing. For the last 4 years we have held a 9-week Summer Academy for Advancing Deaf and Hard of Hearing in Computing, which brings deaf students from across the country and teaches them programming and animation skills. We are an NCWIT Pacesetter School and we have an active ACM-W organization in the department. We have produced "day in the life" videos with women graduates of CSE showing the kinds of work and lifestyles they lead; these videos are widely used and linked to by others (see http://www.cs.washington.edu/whycse/) and we've had 750 requests for DVDs from around the world. We typically send 15 or 20 women students (both ugrad and grad) to the Grace Hopper Conference each year.

At the undergraduate level we are hovering around 20-22% women (not good, but significantly better than most of our peers), which is an increase from a steady 15-16% from the first part of this decade. We have set an NCWIT goal of 30%. Some of our new efforts will include direct outreach to local high schools with a UW CSE roadshow, more targeted recruiting to women in our introductory courses, and working on a closer partnership with the First Robotics program here in Washington State. We have encouraged women in the introductory programming sequence 142/143, e.g., through special sections that give a broader view of CS. The graph below shows the increase of women students in 142 and 143 (prog 1 and prog 2).



On the other hand, our faculty has only 6 tenure-track women (14% of tenure-track faculty): Su-In Lee, Magda Balazinska, Yoky Masuoka, Anna Karlin, Linda Shapiro, and Susan Eggers. We also have an instructor, Barbara Mones, who teaches animation, and this year we have two women part-time instructors. Eggers is close to retirement, and both Linda and Su-In are joint appointments. Hiring women faculty has been (honestly) challenging for multiple reasons, including a shortage of candidates, area mismatch, and state law that prohibits any special programs for addressing the problem. The university has not been necessarily supportive, either; e.g., several years ago when we had two strong women candidates but a position for only one, we asked the Acting Provost to allow us to make two offers and to provide a position only in the case that both accepted, and he refused (although we still made one offer and hired Magda Balazinska).

Section II: Teaching and Learning

A. Educational philosophy

The Department has always had a deep commitment to its educational mission at all levels. We were the winners of the inaugural University of Washington Brotman Award for Instructional Excellence – essentially a departmental Distinguished Teaching Award, created in 1999 through a gift from Regent Jeffrey Brotman and his wife Susan.

CSE's educational efforts are shaped by a four-point philosophy (originally articulated in our nomination for the Brotman Award):

- We believe that universities are, first and foremost, educational institutions, and that faculty members are, first and foremost, educators. Students are the "product" of the university and its faculty, in both senses of the word: they are the "output," but more importantly they are the

multiplier that provides leverage for every faculty member.

- We believe that a *research* university is a unique institution that can provide a unique undergraduate education – an education in which bright and committed students are brought to the very forefront of knowledge, closely mentored by faculty who are (with their students) working to redefine that forefront. More importantly, we believe that a research university *must* provide this kind of education, because no other institution can, and because any other kind of education can be provided better and/or cheaper elsewhere.

- We believe in taking a holistic view. Today's K-12 students are tomorrow's UW students; we must give them the tools to succeed. UW's future is inextricably linked to the future of our region; creating a climate conducive to a 21st-century technology-based economy serves everyone's interests. Special responsibilities fall to computer science programs as we approach the millennium, because of the role that computer science is playing in transforming all aspects of our lives; we must rise to these responsibilities.

- Finally, we believe that UW's highly capable students, staff, and faculty will respond to encouragement and example, striving for excellence in response to high expectations. Our educational efforts and approaches follow directly from these principles. We strive to create the best possible educational experience for our students – one that benefits from, *and that benefits*, our position as a top-ten research program.

In summary, our overriding objective is to do the things that only we can do, and to do them as well as they can be done.

B. Overview of programs

An accounting of our range of educational programs reveals 6 major categories:

- *Introductory curriculum* – consisting of a total of three courses, two in introductory programming that are university-wide service courses attracting approximately a third of the UW's undergraduate population, and one in information technology fluency intended to reach even more students.
- *Undergraduate majors programs* – we offer two undergraduate degrees, Computer Science from the College of Arts and Sciences and Computer Engineering from the College of Engineering. The two programs have a similar core but different requirements and senior capstone experiences.
- *Undergraduate non-majors programs* – our six non-majors courses provide important material for students from several other departments (esp. EE) and constitute the "computer science" track of the Applied and Computational Mathematical Sciences program (http://www.math.washington.edu/acms/) offered by our colleagues from Applied Mathematics, Mathematics, and Statistics.
- *Five-year combined BS/MS program* – in 2008 we began offering a small five-year MS program for our promising juniors, who coordinate their 4^{th} and 5^{th} years to allow a deeper and broader experience. Unfortunately, this program was not funded by the UW and we are left with a program less than one quarter of the size we intended.

- *Professional MS program* – we provide an evening program for working IT professionals from the area's extensive industrial base that allow them to complete an MS in 3 years by completing one course per quarter (meeting one evening per week).
- *Full-time graduate program* – we focus on admitting students with the greatest potential for doing leading research with approximately 57% graduating with a PhD and the remainder with an MS. These students form the core of our research enterprise.

The table below shows current statistics for our programs. In summary, our department's student community, i.e., those students that call our department their home, total approximately 900 including undergrads, PMP, and full-time grad (Ph.D.), in any given year.

Program	**Total enrollment**	**Applications per year**	**Admitted per year**	**Enroll per year**	**Graduates per year**
Introductory	3200	n/a	n/a	n/a	n/a
Ugrad major	560	473	175-180	170-175	160
Ugrad non-major	415	n/a	n/a	n/a	21 (ACMS-only)
Combined BS/MS	27	35-45	11-12	10-11	10
Professional MS	155	114	54	54	45
Full-time grad	161	1100	85	25-35	23

Introductory Program Details. We continue to use several different mechanisms to ensure that we attract the best students into our programs, casting our net as widely as possible in two ways. First, we use our introductory programming courses (CSE 142 and CSE100) to introduce students to the "real" business of computer science and engineering and the many exciting opportunities that are available to them; these classes are taken by about one third of UW's new students. We have a strong focus on identifying and encouraging students from under-represented populations via special sections and seminars. The result is that more students than ever are applying to our program.

Undergraduate Program Details. Our undergraduate programs are managed by an undergraduate faculty advisor who oversees one lead staff advisor, 2.5 FTE staff advisors, and a course coordinator for CSE introductory courses. The department's undergraduate advising unit has four principal functions: recruit the best possible students into our major programs, help them succeed in their goals, ensure that they graduate in a timely manner, and help other students find suitable options.

We take active steps to encourage our students to participate in co-op programs and other industry internships. Currently, roughly two-thirds of our undergraduates participate in co-ops or internships. We host a large number of events where local industry affiliates describe what their companies do and describe internship and employment opportunities waiting for them. We hold workshops on resume writing and interviewing skills. We also encourage students to become involved in the academic enterprise, both in research and in teaching. Nearly one-third of our students are engaged during their undergraduate years in independent study or as research assistants working alongside graduate students, postdocs, and faculty. Our undergraduates also serve as teaching assistants for many of our courses, and an undergraduate category has been added to our highly-prized Bob Bandes Teaching Award for teaching assistants.

Approximately one quarter of our undergraduate students are double majors and we strive to provide them with flexibility in our requirements to encourage education and research in important inter-disciplinary spaces.

Professional MS Program (PMP) Details. In any program for students working full-time, accessibility is essential. All Professional Master's Program (PMP) courses are offered in the evenings and some classes are offered via distance education. The distance learning courses utilize integrated web and videoconferencing technologies between sites at UW and Microsoft in Redmond. Both degree structure and individual courses have been designed with the working students in mind. The degree requirements are coursework-only with no thesis or projects outside of classes. To allow flexibility for students, there is no prerequisite structure between the courses, nor are there course distribution requirements. The courses generally have the same coverage and rigor as courses in the full-time graduate program, but projects are scaled back since the assumption is that students in the program spend their days doing projects.

The PMP has graduated 501 students since its inception in 1996. Approximately 70% of admitted PMP students have Computer Science or Computer Engineering degrees and most of the remaining have degrees in the sciences or engineering. The professional experience of students entering the program ranges from 1 to 25 years. PMP students represent a diverse collection of companies, currently drawing from 34 firms. Enrolled students have excellent undergraduate GPAs (a 3.6 average for all students) and GREs. The graduation rate has held steady at 85%.

Full-time Graduate Program Details. We receive approximately 1100 completed applications to our full-time graduate (Ph.D.) program and admit about 80 of these. Approximately 25-35 typically accept our offer. We only lose significant numbers of students to the top-four departments – MIT, Stanford, Berkeley, and CMU. The average GRE scores of matriculants, averaged over several recent years, tend to be approximately 90% Verbal, 92% Quantitative, and 47% Analytical.

We promise students funding for their first 3 years of study, although as a practical matter no student goes unfunded. Among all students in the program, roughly 20% are supported on fellowships, 68% by research assistantships, and 12% by teaching assistantships (two TA quarters are required).

Roughly one-third of our student body consists of international students. About one-fourth of our full-time graduate students are women and only 4% are minority students (African-American or Hispanic-American).

All aspects of the graduate program are oriented towards immersing students in research. Over time, our view of how best to accomplish this changes. For example, we have made changes to the Qualifying Evaluation and to the General Examination to control what we perceive to be a lengthening of the time to Ph.D. and to respond to the changing preparation and the desire of incoming graduate students to start research earlier. We reduced the number of courses required for the qualifying evaluation from eight to six (with no change to the total number of courses required for graduation) so entering students could take one course and conduct research simultaneously during their initial quarters. Furthermore, the added flexibility permits more inter-disciplinary activity.

At the same time, we placed a stronger limit on the time to complete the qualifying examination – which involves demonstrating breadth and excellence in coursework and completing and presenting an independent project. It must now be completed within 1.75 years of entry to the program unless a petition for extension is granted. The General Examination – which has a variety of formats centered around integrating the literature in an area – must now be initiated within three years of entry to the program or within one year of completing the Qualifying Evaluation (whichever is later), and has duration limited to two months. In each case, the goal is to control "scope creep" and move students more rapidly through the decision points that mark the path from entry to PhD. In examining the records of the 423 students who entered our full-time graduate program between Autumn 1996 and Autumn 2009 inclusive, we find that 242 have left the department and 145 are still enrolled. Of the 242 departed students 57% completed a Ph.D. and 43% completed a Masters. Average time to graduation for the PhD is 6.25 years while for the MS degree it is 2.00 years.

We are generally pleased with our full-time graduate program and at the same time have ever-increasing aspirations. In the past decade we have regularly produced graduates who were among the most sought after in the nation. Regularly we produce graduates in the very next echelon. We view our students as a collective responsibility and we pride ourselves on sending well-educated, well-prepared, already-known graduates onto the interview circuit.

C. Educational highlights

Remodeling of our undergraduate core curriculum. Based on conversations with our external advisory board in 2009, we undertook a major overhaul of our core courses at the 300-level. In essence, we moved from a traditional "stovepipe" model where each course focused on one set of concepts, to a model where concepts from different areas are presented together to highlight the interaction and interplay between these core concepts. For example, we now teach a course – CSE351: The Hardware/Software Interface – that introduces topics from programming languages, compilers, computer architecture and operating systems as a coherent set of ideas. We started transitioning to these new courses during the 2009-2010 academic year and plan to complete the transition by the end of the 2010-2011 academic year. We are excited about these new courses and the innovation they have spurred. This revamping of the curriculum has also allowed us to modify the graduation requirements to make them substantially more flexible. This reflects the changing nature of our field, which has seen an explosion in new applications of computer science and engineering and opportunities for collaboration and impact in other fields, such as the bio-sciences, environmental sciences, global health, and economic development. We do provide direct advice for students in terms of recommended course sequences they should follow for specific career goals.

The number and diversity of courses in our programs continues to increase and to reflect the increasing interface with other disciplines. For example, we now have extensive offerings in human-computer interaction and machine learning at both the undergraduate and graduate levels. We have expanded our offering in computer engineering with the hiring of joint faculty with EE under the ExCEL program. This includes a new introductory course on signal conditioning offered through the EE department as EE205 but also staffed by CSE faculty.

Capstone courses. Our undergraduate curriculum is tiered such that there is a common core of sophomore/junior-level courses on which all of our senior-level courses are layered. Capstone design

courses reside above some of the senior-level courses providing integrative design experiences in myriad areas. Class sizes are progressively smaller as students move through the program, ranging from 60 in some of our common core courses down to 15 or 20 in many of our capstone courses.

Our capstone courses have been particularly effective at giving our students a sense of what it means to develop solutions to open-ended problems. The department now offers over a dozen different capstone courses, averaging about 8 annually. The topics range from technology for accessibility to technology for the developing world to robotics and video games. Many of the courses are inter-disciplinary. For example, the capstone on developing world applications is a two-quarter sequence that begins with problem identification with a mix of students from CSE, the iSchool, and HCDE and finishes with a CSE intensive prototype creation phase. Many of the projects lead to publications and even actual deployments, e.g., a low-cost ultrasound system with a user interface specifically designed for rural midwives in sub-Saharan Africa.

Five-year combined BS/MS program. In 2008 we requested that the provost fund a new 5-year BS/MS program that would produce 30 MS graduates per year. At the time she agreed to fund only a "test drive" of 10 students per year, and shortly after that time this funding was lost in the wake of significant budget cuts. We have honored our commitment to our students to continue this highly attractive (but small) program, but there are too few students to justify new course creation. We therefore enroll these students in a combination of full-time graduate program courses, PMP courses, and capstone design courses. This is much less than ideal as the goals of the students in these groups are quite different. While this program was intended to be industry focused, a number of students have joined research programs, become interested in research careers, and applied to graduate Ph.D. programs in their 5th year. Fifth year students have also served as TAs for undergraduate courses.

Admission and student demand. It was traditional for UW students to apply to majors at the end of their sophomore year – an unfortunate situation encouraged by Washington's higher education policy that anticipates a large number of community college transfers. In recent years, we have lead an effort to change this significantly by ensuring top UW admits direct entry to the major ("direct admits") – an approach now being adopted by other COE programs, which encourages many of Washington's promising students to choose UW. We have also instituted "accelerated admission" to the major for students who perform particularly well in our introductory programming courses. These students can now gain admission to the major as early as the start of their sophomore year. Together, these two admission categories now account for around half of our admissions. This is particularly important; students can better plan their major requirements and are more likely to consider and undertake research and cooperative education experiences that enhance their education.

Demand for our major programs continues to exceed capacity by a significant margin. Our majors are outstanding and comparable to those in the best programs nationally. It is our commitment to provide these outstanding students the education they deserve – a mission that we believe best serves the needs of the State of Washington. We have sought to increase our major numbers based on this consistently high demand. However, we have not been able to secure funding for this expansion (a planned undergrad increase of 65 FTE was recently rolled back due to budget cuts).

Finally, increasing interest in our field, due to its nature as a universal tool for all the sciences and many of the arts and humanities, is also encouraging us to add additional courses to meet this need.

These include our IT fluency course (which serves as a national model) and new offerings such as web programming and MATLAB programming made available to our own majors as well as the many UW students that have completed our introductory programming courses.

Section III: Scholarly Impact

UW Computer Science & Engineering is widely regarded as one of the top ten programs in the nation. Twenty-nine current CSE faculty members have won Presidential/NSF Young Investigator Awards or NSF CAREER Awards. Five faculty members are ONR Young Investigator Award recipients. Four have held NSF Presidential Faculty Fellow or Presidential Early Career (PECASE) Awards. Fifteen have held Sloan Research Fellowships. Two have held Packard Fellowships. Two are Microsoft Faculty Fellows. Two have been honored by Technology Review TR-35. Among the senior faculty are eight Fulbright recipients, two Guggenheim recipients, fourteen Fellows of the ACM, ten Fellows of the IEEE, two Fellows of the International Association for Pattern Recognition, three Fellows of the Association for the Advancement of Artificial Intelligence, two Fellows of the American Association for the Advancement of Science, one Fellow of the American Academy of Arts & Sciences, one MacArthur Fellow, and two Members of the National Academy of Engineering.

A: Impact of research and creative work

Here we describe major research accomplishments of our programs, broken down by our major research areas.

Computer Architecture (Jean-Loup Baer (emeritus), Luis Ceze, Carl Ebeling, Susan Eggers, Hank Levy, Mark Oskin, Larry Snyder (emeritus)): In the past 5 years, our computer architecture group has had success on several fronts. We developed WaveScalar, the first data-flow architecture that profitably executes imperative programs, which involved solving open problems in memory ordering and tiled organizations. We pioneered multiprocessing systems that execute multithreaded programs *deterministically*, which changes the landscape on debugging, testing and deploying multicore software. We developed architectures that can automatically detect and avoid concurrency errors. We also developed the first synthesis compiler to create a profitable caching subsystem from applications written in C (rather than a hardware description language). Notably, all our major research results are across the stack, involving architecture, OS, and programming languages/compilers. We've had steady success in publishing in the top conferences (ISCA, MICRO, ASPLOS), including 4 papers (over 13% of the program) in ISCA '08, and multiple "Top Picks Awards." We successfully transferred the deterministic multiprocessing and bug avoidance technologies to a spinoff company, Corensic, which now employs over a dozen people in the Seattle area and has its first product.

Systems and Networking (Tom Anderson, Magda Balazinska, Gaetano Borriello, Luis Ceze, Steve Gribble, Yoshi Kohno, Arvind Krishnamurthy, Ed Lazowska, Hank Levy, Alan Shaw (emeritus), David Wetherall, John Zahorjan): The systems and networking group has continued its long history of success and community leadership. Our taste in research includes problems with immediate industrial impact, such as improving the robustness of Web browsers (which influenced Google Chrome) and OS device driver architectures (which influenced Microsoft), as well as problems that will shape future

systems over multiple decades, such as ingraining incentives into the design and evaluation of networking protocols and distributed systems. Our faculty has a remarkable breadth of expertise and capitalizes on it with its culture of collaboration; because of this, our recent work ranges from exploiting interference cancellation as a way to improve wireless network efficiency and speed, to designing new operating systems for multicore computers that guarantee deterministic execution in spite of hardware non-determinism. Our papers are influential, often being the first to identify new research areas that the community engages; as a result, we have won 20 best paper awards over the last decade at top venues like SIGCOMM, SOSP, OSDI, IEEE Security and Privacy, MobiSys, and NSDI, and Test-of-Time awards from SIGCOMM, SIGOPS, SIGARCH, and SIGMETRICS. As of last April, four of the top ten ranked OS authors on Microsoft Academic Search were UW CSE faculty members. (Lazowska has since been de-throned.) We also spun off a successful startup in the cloud computing space (Skytap).

Security and Privacy (Tom Anderson, Michael Ernst, James Fogarty, Steve Gribble, Dan Grossman, Yoshi Kohno, Arvind Krishnamurthy, James Landay, Hank Levy, Dan Suciu, David Wetherall): Over the past 5 years UW CSE as emerged as a leader in computer security and privacy research. UW CSE has done pioneering work on a diversity of fields ranging from security and privacy for emerging technologies to Web and Internet security. We conducted the first wide-scale analysis of malware and spyware on the Web; we provided the first experimental security assessment of wireless implantable medical devices and modern automobiles, we initiated a new research direction for ensuring that data on the Web does not persist longer than the users intend, we provided key results for protecting the Internet against denial-of-service attacks, and we constructed a large laboratory for monitoring malicious botnets. The impact of this research has been recognized both within the research community (e.g., multiple best paper awards at top conferences) and the public at large (e.g., at least seven separate projects have been featured in *The New York Times* over the past four years alone, and numerous other projects were covered in other media outlets).

Programming Systems and Software Engineering (Luis Ceze, Susan Eggers, Michael Ernst, Dan Grossman, David Notkin, Alan Shaw (emeritus), Larry Snyder (emeritus)): We have produced a set of key results including a programming language approach to defining and checking architectural properties in source code (ArchJava), foundational work on software transactional memory to simplify parallel programming, a framework for defining provably correct compiler optimizations, an industrial-strength approach to type annotations for Java, approximate and lightweight analysis techniques as a basis for software tools, dynamic analysis techniques for discovering program invariants, and more. Our faculty provide leadership through program committees (frequently serving for OOPSLA, POPL, PLDI, ICSE, FSE, ISSTA, etc.), conference leadership (general chair of the 2013 International Conference on Software Engineering), professional societies (membership on SIGPLAN Executive Committee and ACM Education Council, past-chairship of ACM SIGSOFT), etc.

Mobile and Ubiquitous Systems (Magda Balazinska, Gaetano Borriello, James Fogarty, Bruce Hemingway, Yoshi Kohno, James Landay, Richard Ladner, Shwetak Patel, Josh Smith): Our research on activity-centric ubiquitous computing has been leading the field over the last five years. This work is centered on the idea of sensing people's everyday activities in the physical world (through both mobile and *in situ* sensors) and using this information to help improve their lives. The research has spanned from sensing and inference to new input devices to applications in areas as diverse as encouraging better environmental behavior, getting more regular exercise, real-time

information about public transit, making cell phones accessible to people who use sign language, and allowing elders to age in place. UW research has regularly appeared at the top conferences such as CHI, UbiComp, and Pervasive (12 papers in the last 3 years with 3 of these being "best papers"). This work also shows the impact of our long-term collaboration with the off-campus Intel research laboratory, as much of the early work came out of joint projects between CSE and Intel. We have two TR-35 winners in this area: assistant professor Shwetak Patel and recent graduate Scott Saponas (now at Microsoft Research). More recently, our work in this area is turning to helping people be more aware of their energy usage and has led to a major licensing of UW technology to Belkin.

Human Computer Interaction (Richard Anderson, Alan Borning, Gaetano Borriello, Oren Etzioni, James Fogarty, Richard Ladner, James Landay, Yoky Matsuoka, Shwetak Patel, Zoran Popovic, Raj Rao, Steve Tanimoto, Dan Weld): Within the past 5 years, UW and UW CSE have quickly emerged as one of the world's top centers for HCI research. Our efforts are organized around DUB, a cross-campus alliance of faculty and students together with our industrial research partners. This interdisciplinary approach has allowed UW to lead in both quantity and quality. Specifically, UW has been one of the top universities for the number of papers appearing at CHI 2008, 2009, and 2010. UW has also won more CHI Best Paper awards than any other institution (winning 6 since the award began in 2005). UW is one of the leading centers in the world for accessibility research – HCI research that focuses on innovation and evaluation of technologies for people with disabilities. Between 1994 and 2009 there have been 94 papers from UW at ACM ASSETS, the leading accessibility conference. The second-leading academic institution has only 57. UW students have won best paper awards at ASSETS three out of the past five years.

Computer Graphics, Computer Vision, and Animation (Brian Curless, Barbara Mones, Zoran Popović, Steve Seitz, Linda Shapiro): The computer graphics, computer vision, and animation faculty focus on the areas of animation, games, computational photography, object recognition, and 3D reconstruction from images. In the past five years, the group's research has had substantial impact in many ways, including publication of 60 papers at the very top computer graphics and vision conferences. The faculty have given numerous Distinguished Lectures and Keynotes at leading universities and conferences during this time. Big research successes have also led to impact through technology transfer; highlights include the technology behind Microsoft's high profile *Photosynth*, groundbreaking crowd simulation work licensed to Electronic Arts, and the DraftTrak air-flow visualization used by ESPN for televised NASCAR races. In the last 5 years, both Adobe and Google have created new research groups led by CSE graphics and vision faculty, and populated largely by former CSE students and postdocs. Finally, research in animation and games has had broad impact beyond traditional computer science. FoldIt (http://fold.it), an online game that enables people to solve protein folding problems, has been a high profile success in the field of biochemistry and in the media, including a recent article in *Nature*. And Refraction, a game for teaching children fractions, won the prestigious Grand Prize in the Disney Learning Challenge.

Data Management (Magda Balazinska, Pedro Domingos, Mike Ernst, Oren Etzioni, Mausam, Dan Suciu, Dan Weld): The data management group comprises four core faculty, about a dozen collaborating and Affiliate faculty, and eleven students with thesis topics directly in the area. The group is especially well known for seminal work in the areas of stream processing, probabilistic databases, information extraction and integration, XML processing, model management, and more recently data intensive and cloud computing. Faculty and Affiliates in the group have received

numerous awards including a 10-year best paper award at PODS (2010), the best paper award at SIGMOD (2000), two best paper awards at KDD (1998 and 1999), and the 10-year most influential paper award at WCRE 2010. In addition to seminal work, the group is also contributing to the data management communities through regular conference organizations. Group members are regular PC members at PODS, SIGMOD, KDD, VLDB, ICDE, and ICDT. Additionally, representatives of the group have been PC chair at PODS 2004, PC co-chair at ICDE 2007 and KDD 2003, vice chair at WWW 2005, ICDE vice chairs in 2001, 2009, and 2010.

Artificial Intelligence and Robotics (Pedro Domingos, Oren Etzioni, James Fogarty, Dieter Fox, Su-in Lee, Yoky Matsuoka, Mausam, Raj Rao, Steve Tanimoto, Emo Todorov, Dan Weld, Luke Zettlemoyer): Our AI research has generated international recognition in the areas of machine learning, probabilistic reasoning, robotics, automated planning, natural language understanding and intelligent interfaces. Our Softbots project pioneered the use of the Internet as a real-world environment to test intelligent agents and led to novel algorithms for planning under unbounded uncertainty. Other innovations include open information extraction, Markov logic for performing statistical relational learning, particle filters for complex estimation problems in robotics, bio- and neural-inspired robotic algorithms for rehabilitating and assisting humans, adaptive interfaces that increase the efficiency of users with physical handicaps, and probabilistic data-mining methods for analyzing the 4000 year old Indus script. AI faculty provide leadership by chairing international conferences (e.g., AAAI (twice), KDD, IUI, RSS (twice)), guiding professional societies (e.g., membership on the AAAI Executive Council (twice)), and taking editorial positions at *IEEE Transactions on Robotics*, *JACM* and *JAIR* (thrice) as well as serving on many editorial boards. CSE's AI faculty have started 8 companies, including Farecast (now Bing Travel).

Theory of Computation (Dave Bacon, Paul Beame, Aram Harrow, Anna Karlin, Richard Ladner, James R. Lee, Anup Rao): The theory group has interests and expertise in most foundational aspects of CS, as well as on theoretical aspects of application areas. Some of our seminal results in the last few years include: (i) the development of a new quantum error-correcting code that significantly reduces the resource requirements for building a reliable quantum computer (Bacon); (ii) the resolution of a number of long-standing open questions concerning random walks on graphs, the solution of which required the development of a fascinating new set of techniques related to Gaussian processes and Talagrand's theory of majorizing measures (Lee, with Ding and Peres); (iii) the first progress on a longstanding and fundamental open question in communication complexity (Rao, with Barak, Braverman and Chen); (iv) the development of a generic polynomial time approximation algorithm that achieves the optimal approximation ratio for *every* constraint satisfaction problem and a wide variety of other optimization problems, assuming the Unique Games Conjecture (Raghavendra); and (v) the resolution of one of the central open questions in algorithmic coding theory – optimal error correction in an adversarial noise model (Guruswami and Rudra).

Computational & Synthetic Biology (Su-In Lee, Yoky Matsuoka, Zoran Popovic, Raj Rao, Larry Ruzzo, Georg Seelig, Linda Shapiro, Martin Tompa): Members of the Computational & Synthetic Biology research group have expertise that spans a wide range of topics, from molecular biology (genetics of complex traits, biological sequence analysis, comparative genomics, synthetic biology) to human biology (computational neuroscience, biomedical imaging, neurobotics). Publications resulting from our research have been highlighted in the most influential science journals, including *Science*, *Nature*, *Nature Biotechnology*, *Nature Neuroscience*, *Proceedings of the National Academy of*

Sciences, and *Genome Research*. It is notable that ours are papers with a significant computational component appearing in journals that do not cater to such work. We have produced software (freely available) that is used regularly by biologists worldwide and has resulted in the discovery and characterization of hundreds of new and important biological molecules and molecular interactions.

Computing for Development (Richard Anderson, Tom Anderson, Gaetano Borriello, Ed Lazowska): Our first Ph.D. graduate in this area was Tapan Parikh in 2007, who did a ground-breaking dissertation on the application of mobile phones in the management of micro-loans in India. More recently, UW has become one of the top departments internationally in the ICTD (Information and Computing Technology for Development) field with several high-profile projects and many publications at the recent ICTD conferences and the new ACM DEV conference. Open Data Kit, a smartphone-based open-source data collection and decision support toolkit, has found wide acceptance in applications ranging from community health worker programs to human rights monitoring to climate change. Digital Green is a model for the application of tutored video instruction (TVI) in agricultural education. The Change group at UW serves as an interdisciplinary meeting point for ICTD activities across campus and brings together researchers in CSE, the iSchool, HCDE, Public Health, Global Health, the Foster School of Business, and the Evans School of Public Affairs.

B. Impact by students in the program

UW CSE attracts extraordinary students at both the undergraduate and graduate levels. In the past decade our undergraduates have included a Rhodes Scholar, a Rhodes finalist, and two UW Rhodes nominees. Five undergraduates have won Goldwater Scholarships. We have had one Marshall finalist, and two UW Marshall nominees. We have had a Putnam Fellow, a UW Gates Cambridge Scholarship nominee, and a Google Anita Borg Scholar. Each year, the University of Washington awards four "high scholarship" medals, to the top student (out of 5,500-7,500) in each class. In the past decade CSE undergraduates have won two Freshman Medals, five Sophomore Medals, four Junior Medals, and one President's Medal (the Senior Medal for the top graduating student). The Dean's Medal recognizes the top senior in the College of Engineering, and the top senior in each of the College of Arts & Sciences four divisions. In the past decade CSE undergraduates have won four Dean's Medals in Engineering, three Dean's Medals in the Sciences, and one Dean's Medal in the Arts (a triple major in CSE, Music Theory, and Piano Performance!). In the past decade, *thirty three* CSE undergraduates have been recognized in the Computing Research Association's Outstanding Undergraduate Researcher Award competition – a greater total than any other university.

In the past decade, 33 CSE graduate students have held NSF Graduate Fellowships; 15 have held Microsoft Research Ph.D. Fellowships; 14 have held Intel Ph.D. Fellowships; 6 have held IBM Ph.D. Fellowships; 9 have held NDSEG Fellowships; 5 have held NSERC Fellowships; 11 have held Google Anita Borg Fellowships; 2 have held MSR Women's Scholarships; 4 have been recognized by TR35 awards for work done while in our graduate program; 7 have received competitive fellowships from the UW College of Engineering; and 31 have received competitive fellowships from the ARCS (Achievement Rewards for College Scientists) Foundation; plus a number of other fellowships, including the first Google Fellowships in Networking and in Cloud Computing. Four CSE graduate students were recognized by the University of Washington Graduate School as top Ph.D. graduates across the university, and five received significant national or international awards for their research.

Computer Architecture: Our group has been extremely successful in the last five years at placing its graduate students into positions in academia and industry, notably Steve Swanson (2006, now UCSD), Martha Mercaldi-Kim (2008, now Columbia), and Andrew Putnam (2008, now Microsoft Research). Masters students have taken positions at Google, AMD, and University of Toronto (lecturer). Undergraduate students working in the computer architecture lab have gone on to the Medical School at Columbia, to the Berkeley Ph.D. program, to Microsoft, and to Amazon.

Systems and Networking: Our greatest success continues to be the success of our students. Over the last decade many of our students have taken faculty positions, including Geoff Voelker (2000, now UCSD), Stefan Savage (2002, now UCSD), Gun Sirer (2002, now Cornell), Alec Wolman (2002, now MSR), Robert Grimm (2002, now NYU), Neil Spring (2004, now Maryland), Stefan Sariou (2004, first University of Toronto and now MSR), Krishna Gummadi (2005, now Max Planck Institute for Software Systems), and Mike Swift (2006, now Wisconsin). Charles Reis (2009) implemented the process structure in Google Chrome browser as part of his Ph.D. and is now at Google. Ratul Mahajan (2005, now MSR) recently won the ACM SIGCOMM "Rising Star" award for his measurement-driven contributions to networking management and wireless communication. A vast amount of the energy and expertise in our group derives from our exceptional current graduate students, such as Roxana Geambasu, who is finding ways to give users control over their data in spite of the rise of cloud and mobile computing. We are involved with undergrads as well, such as Amit Levy, who is co-author on a recent OSDI paper on extensible distributed storage systems, and Justine Sherry, the 2010 CRA Outstanding Undergraduate Researcher awardee, now a graduate student at UC Berkeley, who devised new Internet measurement techniques.

Security and Privacy: Our research and education program is young, and thus we are only starting to develop a pipeline of students in computer security. For example, the undergraduate security course was introduced in Winter 2008 and the graduate course in Autumn 2008. Since 2008 we have sent a team to the Pacific Rim Regional Collegiate Cyber Defense Competition; our team of eight students (at least six undergrads) won 1st place every year (2008, 2009, and 2010). The undergraduate computer security course has received national attention for its novel approach to helping students develop the computer security mindset; this course received widespread media discussions following an article about the course in Wired.com. UW CSE is thus providing a model for undergraduate computer security education; the approach we pioneered has been adopted by many other institutions. Undergraduate and graduate students are also highly involved with research. One undergraduate security researcher received an NSF Graduate Research Fellowship, and current UW CSE graduate students have received an NSF Graduate Research Fellowship, a Microsoft Woman's Scholarship, and a Google Ph.D. Fellowship. Over the past five years, UW CSE graduate and undergraduate students have been authors of multiple award papers at top conferences, and the students' research has been widely discussed both in the media and within the research community.

Programming Systems and Software Engineering: Graduate students in programming languages and software engineering provide industrial and academic leadership. Our former Ph.D., Jeff Dean, a Google Fellow and member of the National Academy of Engineering, is widely known for his broad-based contributions to Google's scalable infrastructure. Michael Ernst (tenured at MIT before returning to join our faculty) received the inaugural John Backus Award from IBM Research for his research contributions to enhancing programmer productivity, as well as honorable mention in the ACM Doctoral Dissertation Award competition for his groundbreaking work in dynamic approaches

to discovering program invariants. (The late William Chan also received honorable mention in that competition the same year, for his work in software model checking). Gail Murphy (U. British Columbia) has a host of awards including the highly prestigious NSERC Steacie Fellowship and the CRA-W Anita Borg Early Career Award. Murphy also won the inaugural AITO Dahl-Nygaard Junior Prize for research in object-oriented systems, and two years later our alum Jonathan Aldrich (Carnegie Mellon) won the second one awarded. Other graduates are thriving at UCLA (Todd Millstein), UCSD (Bill Griswold and Sorin Lerner), UT Austin (Miryung Kim), IBM (David Grove), Intel Labs (Matthai Philipose), University of Virginia (Kevin Sullivan), North Carolina State University (Tao Xie), etc.

Mobile and Ubiquitous Systems: Graduate students in mobile and ubiquitous systems have mostly gone to industry research positions at some of the top labs in the field including Microsoft Research (Scott Saponas, a TR35 winner), Intel Labs Seattle (Jeff Hightower), Palo Alto Research Center (Kurt Partridge), Nokia Research (Evan Welbourne), and Google Seattle (Harlan Hile, Yang Li). Several have gone on to form or join local startup companies (Ross Ortega and Ken Hines starting Consystant, Alan Liu joining Kiha). On the academic side, Robert Grimm is tenured at NYU, Pai Chou is a tenured faculty member at UC Irvine and Jonathan Lester is a post-doc at MIT.

Human Computer Interaction: The depth of UW CSE and the breadth of DUB have been a powerful combination for our HCI students. In addition to their many award papers, CSE HCI students have won several other major awards; e.g., Scott Saponas and Jeff Bigham have both been recognized in MIT Technology Review's TR35. Three students have won Microsoft Graduate Fellowships since 2008 (Jon Froehlich, Scott Saponas, and Kayur Patel). HCI graduate students have gone on to strong faculty positions (e.g., Eytan Adar at Michigan, Jeff Bigham at Rochester) and top industrial labs (e.g., Susumu Harada at IBM Research, Scott Saponas at Microsoft Research). Many undergraduates are active in HCI research, including some who have gone on to top graduate programs (e.g., Julia Schwartz now at Carnegie Mellon). As HCI continues to mature within UW CSE, we expect even more great outcomes for our students.

Computer Graphics, Computer Vision, and Animation: Students graduating from our group have thrived. Many undergraduates, after doing research in the group, have gone on to top graduate programs including Stanford, MIT, Berkeley, and CMU. The success of Ph.D. students has been striking, taking faculty positions at CMU, Cornell, Princeton, Georgia Tech, Wisconsin, National Taiwan University, and Waterloo, as well as many jobs in top research labs such as Microsoft Research, Adobe Research, and the Nokia Research Center, and R&D positions at production companies such as Pixar and Industrial Light and Magic. A number of alumni have received major awards, among them: Hugues Hoppe (MSR; SIGGRAPH Computer Graphics Achievement Award), Per Christensen (Pixar; Technical Academy Award), Brett Allen (ILM; Technical Academy Award), Aseem Agarwala (Adobe Research; ACM Dissertation Honorable Mention), Noah Snavely (Cornell; ACM Dissertation Honorable Mention), Li Zhang (Wisconsin; NSF CAREER, Sloan, Packard), Karen Liu (Georgia Tech; NSF CAREER, Sloan, TR35), and Adrien Treuille (CMU; NSF CAREER, TR35). Finally, a number of postdocs have gone on to faculty positions (Harvard, Toronto, Hebrew University, TU Darmstadt) and top industrial R&D labs (Adobe Research, Google).

Data Management: Students and postdocs in the database group have received numerous prestigious awards. AnHai Doan won the ACM Doctoral Dissertation Award (2003); Gerome Miklau and Christopher Re received the ACM SIGMOD Best Dissertation Award in 2006 and 2010

respectively (and Nilesh Dalvi was a runner up in 2008); Alexandra Meliou, a postdoc in the group, received a Siebel Scholarship; Kristi Morton and Julie Letchner both received Google Anita Borg scholarships. Multiple students were awarded NSF and NDSEG Graduate Fellowships. Graduating Ph.D. students commonly get jobs at the top academic institutions: Anhai Doan and Chris Re are on the faculty at Wisconsin; Zack Ives is at Penn; Rachel Pottinger is at UBC; Gerome Miklau is at UMass Amherst; Michael Cafarella and Eytan Adar are at Michigan.

Artificial Intelligence and Robotics: Graduate students in AI are leaders in top universities and research labs. Anhai Doan (Wisconsin) won the ACM Distinguished Dissertation Award for his machine learning approach to large-scale schema and ontology matching. Mausam (UW) received an honorable mention in the ICAPS Best Dissertation competition for his thesis on stochastic planning with concurrent, durative actions. Krzysztof Gajos (Harvard) showed that decision theory applied to an automatically learned user model could personalize interfaces, thus saving users considerable time and effort. Don Patterson (UC Irvine) developed activity recognition software, the Activity Compass, a seminal form of context-aware computing; he is Program Chair for UBICOMP 2011. Other graduates are thriving at Michigan (Eytan Adar), Northwestern (Doug Downey), IBM Research (Tessa Lau), Microsoft Research (Matt Richardson), Google (too many to list), and a variety of startups.

Theory of Computation: There has been an exciting leap in the quality and impact of research by our small group of theory students. Prasad Raghavendra's Ph.D. work won both the Best Paper Award and the Best Student Paper Award at STOC 2008 and was referred to as the "best theory paper of the year" on a prominent complexity blog. Atri Rudra's Ph.D. was awarded the William Chan Memorial Dissertation Award (the best Ph.D. thesis in the department) in 2007; his 2006 STOC paper with Guruswami on optimal error correction was invited to the Research Highlights section of the *Communications of the ACM* and was one of three papers highlighted in a news release for STOC 2006 and in the ACM SIGACT annual report for 2006. Ashish Sabharwal (Ph.D. 2005) received an honorable mention in the annual IJCAI-JAIR retrospective award for the best paper published in *Journal of AI Research* five years earlier for his paper (with Beame and Kautz) applying theoretical tools of proof complexity to AI problems. Current Ph.D. students in theory have published eight different papers in FOCS and STOC (the premier and highly competitive conferences in theoretical computer science) over the last three years and have received two NSF Graduate Fellowships, an IBM Graduate Fellowship, a DOE CSGF Graduate Fellowship, a UW Engineering Graduate Fellowship, and a National Physical Science Consortium Graduate Fellowship, among others. Undergraduate William Johnson was named a Putnam Fellow (top five in the Putnam exam, of more than 4,000 entrants) and undergraduates Jenn Hanson and Elizabeth Muhm have been awarded NASA Space Grant Summer Undergraduate Research Program grants.

Computational & Synthetic Biology: Our group has been blessed with creative, productive, and knowledgeable students. These students, which must be experts in both biology and CSE, have created several innovative software tools that are used in the discovery of novel biological molecules and molecular interactions. As an example at the graduate level, Mathieu Blanchette (now McGill) created the FootPrinter program for the discovery of interactions between regulatory proteins and DNA; Mathieu went on to become recipient in 2006 of the International Society for Computational Biology Chris Overton Prize for outstanding accomplishment, the field's most prestigious award for a young scientist (typically awarded within 10 years of Ph.D., but only 4 years post-degree in Mathieu's

case). As an example at the undergraduate level, Shane Neph later created MicroFootPrinter, a front end to FootPrinter that tailored it brilliantly for ease of use by experimental microbiologists.

Computing for Development: The Computing for Development activities are relatively new. Our first graduate in this area, Tapan Parikh, is now on the faculty at the UC Berkeley iSchool. Parikh is a TR-35 "Humanitarian of the Year" (2007), listed among Esquire's Best and Brightest (2008), received the Innovation in Technology Award from the Western Association of Graduate Schools (2008), and the University of Washington College of Engineering Diamond Award for Early Career Achievement (2010). A soon-to-be graduate, Yaw Anokwa, received the Pizzigati Prize, the most significant award in open source software for the public interest, and a Yahoo! Key Scientific Challenges Award, for his work on Open Data Kit.

C: Collaborative and interdisciplinary efforts

For at least two decades we have actively embraced the notion that we must capitalize on our competitive advantages: opportunities to collaborate with top faculty in other units at UW and with top individuals at other organizations in the region. Here are just a few examples:

Microsoft Research: MSR is our longest-established, broadest, and most beneficial collaboration. Close to 30 MSR staff members are Affiliate faculty in CSE; many of these actively participate in research, teaching, and student supervision. A number of CSE faculty members consult with MSR. In a typical summer, between 10 and 20 CSE graduate students are MSR summer interns and spend time at MSR during the academic year. Photo Tourism / Photosynth (http://photosynth.net/) is just one highly visible example of the results of these collaborations. The UW-MSR Center for Theoretical Computer Science (http://www.cs.washington.edu/theory) includes a number of joint projects in Algorithmic Game Theory and applications of Probability and Statistics in Algorithm Design; these interactions have led to new models, algorithms, and mathematical tools that have been publicized in the top venues of their respective fields; the collaboration is internationally recognized as an authoritative source on the use of probability in theoretical aspects of computer science. UW and MSR also jointly organized the Experience Theory Project (http://etp.cs.washington.edu), an event that brought a set of undergraduates with interest in theoretical computer science to Seattle for a three-day weekend over the summer. The UW/MSR Summer Research Institute in Computer Science (http://www.cs.washington.edu/mssi/) annually brings a group of roughly 50 leading computer scientists to Seattle for a multiday retreat focused on some emerging area of the field. MSR has been extensively involved in our eScience efforts.

Intel Labs Seattle: A decade ago, Intel established research labs adjacent to Berkeley, CMU, and the University of Washington, with the explicit goal of facilitating interactions with those computer science and engineering departments. Each lab is co-directed by an Intel employee and a faculty member. The UW CSE faculty co-directors have been Gaetano Borriello, James Landay, David Wetherall, and (currently) Dieter Fox. Intel Labs Seattle has roughly 20 permanent Intel employees and active participation by dozens of UW CSE undergraduate students, graduate students, and faculty, under a collaborative intellectual property agreement that facilitates the easy flow of people and projects. Intel Labs Seattle has helped propel UW CSE to leadership in mobile and ubiquitous systems and in human computer interaction.

Google Seattle: We lobbied Google for several years to open an engineering facility near UW (vs. their original Seattle-area facility across Lake Washington in Kirkland). Brian Bershad's willingness to leave UW to direct the new facility turned the tide. Google Seattle now has roughly 200 engineers, and active participation by UW CSE undergraduate students, graduate students, and faculty, particularly on open-source projects such as the Chrome browser and the Android operating system. Graduate student Charlie Reis contributed to the process structure of Chrome as part of his Ph.D. thesis work. Gaetano Borriello spent a sabbatical at Google Seattle in 2008-09 where he and several students developed Open Data Kit (http://opendatakit.org), now widely used as a data collection and data sharing platform throughout the world. Steve Seitz is currently on leave at Google Seattle building a computer vision group.

DUB (Design, Use, Build): DUB (http://dub.washington.edu/) is UW's cross-campus effort for research and education in human computer interaction and design, bringing together faculty and students from multiple units as well as industrial partners. DUB, whose creation was spearheaded by James Landay in CSE, has led UW's rapid emergence as one of the world's top centers for HCI and Design research, evidenced by the quantity and quality of work appearing at elite HCI venues. DUB is also taking the lead in cross-campus educational efforts, including the design of an undergraduate HCI concentration and ongoing efforts to establish an interdepartmental Masters program. The DUB website shows 35 faculty and 69 students; participating organizations, in addition to CSE, include the Department of Human Centered Design and Engineering, the Information School, the School of Art, Intel Labs Seattle, and Microsoft Research. A small sampling of dozens of recent DUB successes: extending natural gesture-based user interfaces for the home; indoor location tracking for rehabilitation; energy and water monitoring technology for the home; lung function monitoring using a mobile phone; automatic food journaling; and thermal imaging for surface user interaction.

Change: Change (http://change.washington.edu/) is a cross-campus group, originally created by CSE faculty and students, working on information and communication technologies for development (ICTD). The Change vision was inspired by CSE graduate student Tapan Parikh, now a faculty member at UC Berkeley, and is currently organized by senior graduate student Yaw Anokwa. Change brings together participants from academia, government, industry, and non-profits to share knowledge and jumpstart collaborations. Although only in its second year, Change has had a number of successes. Open Data Kit (http://opendatakit.org) is a widely used data collection and data sharing platform, started by Gaetano Borriello and recently funded with a $1.35M Focused Research grant from Google. The project involves over twenty graduate and undergraduate researchers, many of whom are working on deployments with organizations around the world. Computing for Global Health is a collaboration with PATH (http://www.path.org/), a Seattle-based NGO, using technology to improve health in low-income regions. This work began when Richard Anderson spent a sabbatical with the Information Systems group at PATH and has resulted in research projects in Nicaragua, India, and Albania. A project to design and deploy a low cost portable ultrasound device for use by midwives in Uganda was an outgrowth of last year's undergraduate Capstone Design Course and is a close partnership with HCDE and UW Medicine. It recently won a Gates Foundation Challenge Grant that will allow the work to continue into a full deployment phase.

UW eScience Institute: Through the efforts of Ed Lazowska, the University of Washington in 2008 established the eScience Institute (http://escience.washington.edu/) with $1 million annually in permanent funding, to facilitate the generational shift in science from a data-poor enterprise to a data-

rich enterprise, by 1) organizing workshops, lectures, and curricula on data-intensive and cloud computing, 2) fostering collaborative research projects between computer scientists and astronomers, oceanographers, and biologists, 3) establishing campus-wide computing services and infrastructures for researchers, and 4) gathering lessons learned into an online knowledge base. Lazowska serves as Director of the eScience Institute; Bill Howe and Magda Balazinska are heavily involved, as are faculty from more than a dozen UW units. Examples of specific research activities under this umbrella include a $1.5M award from the Gordon and Betty Moore Foundation to researchers at UW and CMU on new systems and algorithms to support data-intensive science, particularly in the emerging field of Astroinformatics; significant support from Microsoft and from NSF for engagement in the data analysis aspects of the NSF Ocean Observatories Initiative; multiple NSF CluE (Cluster Exploratory) awards; and extensive collaborative work between students and faculty in CSE, Physics, and Astronomy on scientific data management in the cloud.

Computational Molecular Biology: Dating from the arrival of Leroy Hood at the University of Washington in 1992, CSE has been actively engaged in a broad range of activities related to computational molecular biology. For example, Martin Tompa is Director of the University's Interdisciplinary Computational Molecular Biology Certificate Program; Su-In Lee, Larry Ruzzo, and Georg Seelig are participating faculty, and many of our graduate students are members of that program. We have a multifaceted collaboration with Hood's Institute for Systems Biology; Hood is an Affiliate Professor in our department, and many students have been involved in collaborative projects at ISB; Larry Ruzzo spent a sabbatical year as a Visiting Scientist at ISB. Ruzzo is also a Joint Member of the Fred Hutchinson Cancer Research Center, where he and his students have collaborated on multiple projects. Su-In Lee has a joint faculty appointment in the Department of Genome Sciences, and Larry Ruzzo and Martin Tompa are Adjunct Professors of that department. They and their graduate students are frequent speakers in that department's Computational Biology seminar series. Joe Felsenstein, Phil Green, Bill Noble, and Maynard Olson of Genome Sciences are Adjunct Professors in our department and active participants in our department's Computational Biology seminar series.

PlanetLab and GENI/OpenFlow: UW CSE – largely led by Tom Anderson and Arvind Krishnamurthy – has been an active participant in the PlanetLab and GENI/OpenFlow consortia, as well as other collaborative efforts in distributed systems and networking. Specific current activities include the design of a scalable and fault-tolerant network manager (in collaboration with Stanford), the design of practical contribution incentives for P2P live streaming (in collaboration with PPLive), troubleshooting CDN performance problems (in collaboration with Google), securing web search engines from malicious hackers (in collaboration with Microsoft), and ISP-friendly P2P traffic engineering (in collaboration with four major ISPs).

Quantum computing: Dave Bacon leads a significant UW CSE collaborative effort in quantum computing. Bacon, the "Quantum Pontiff" (http://dabacon.org/pontiff/), is a key participant in MUSIQC (Modular Universal Scalable Ion-trap Quantum Computer), a $15M IARPA-funded project to build an ion trap quantum computer with 80 qubits which, when completed, will be the largest quantum computer built to date. (MUSIQC involves investigators from UW Physics, Duke, Maryland, Georgia Tech, Michigan, the UBC, and Sandia National Lab.) Bacon has just been joined by Aram Harrow who works at the intersection of physics, mathematics, CS, and information theory.

Access technology: Led by Richard Ladner, UW has become a national center for research and education in access technology – work for which Ladner received the Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring. Three examples of this collaborative work include: (1) the AccessComputing Alliance (http://www.washington.edu/accesscomputing/), started in 2006, which is a collaboration between UW CSE and the DO-IT Center at the University of Washington, and has partnered with numerous other organizations and computing departments to create activities around the country that benefit students with disabilities; (2) the UW American Sign Language Program (http://depts.washington.edu/asluw/) is a collaboration started in 2007 by UW CSE and UW Linguistics, which currently has two ASL Lecturers teaching approximately 130 ASL students, with a waiting list of over 200 more; and (3) the MobileASL project (http://mobileasl.cs.washington.edu/), which is a collaboration between CSE, EE, and the iSchool focused on creating a cellular network based video phone that permits sign language communication at a high enough fidelity and frame rate to be intelligible.

Sensorimotor Neural Engineering: Yoky Matsuoka has built a vibrant regional, national, and international collaboration focused on sensorimotor neural engineering. A 2008 *Workshop on Neural Engineering* sponsored by NSF, UW, and Microsoft Research drew 150 attendees from a broad range of institutions, including nearly 100 from across the University of Washington. Ultimately, this led to an NSF Engineering Research Center proposal that is currently in final consideration involving UW as lead, MIT and SDSU as domestic partners, UBC and the University of Tokyo as foreign partners, and Morehouse, Southwestern, and Spelman Colleges contributing affiliated faculty. The proposed ERC draws its inspiration from the rapid advances in computational technology, the rapid development of novel robotic applications, and the breadth of expertise in these areas and the neurosciences at the partnering institutions. The focus of the effort is to develop integrated systems that assist people with neurological disabilities. These human controlled systems will combine a judicious partitioning of direct neural control (of the system) and some level of autonomous control (by the system).

The major collaborative and interdisciplinary activities described above only touch the surface. Among dozens of smaller efforts are: *Computational neuroscience*, including collaborations with UW Neurosurgery, UW Physics, and UW Physiology, UW Institute for Learning and Brain Sciences, and MSR; *Flexible activity sensing in community-based elder care*, with UW's top-ranked School of Nursing; *Well-behaved implementation of software transactional memory*, with Intel's Programming Systems Lab; *Security and privacy of future wireless implantable medical devices*, with UW's Information School, Beth Israel Deaconess Medical Center, UC San Francisco, Seattle Pacific University, and Oak Ridge National Laboratories; *Urban simulation to inform public deliberation and decision-making*, with UW's Evans School of Public Affairs, Statistics, Information School, and Civil and Environmental Engineering (the resulting system, UrbanSim, is now the most widely used land use modeling system in the U.S.); *Architecture support for concurrency bug detection and avoidance*, with MSR and HP Labs; *Participation in the RAMP (Research Accelerator for Multiprocessors) project* (http://ramp.eecs.berkeley.edu/) to design and build infrastructure for architecture research, which includes 50 researchers at 6 universities; *Shape-based retrieval of 3D craniofacial data*, an effort to provide tools for the study of craniofacial anatomy from CT scans or from a 12-camera photogrammetry system, involving UW CSE, UW EE, UW Biological Structure, UW Medical Education and Biomedical Informatics, UW Pediatrics, and Seattle Children's Hospital; *A unified approach to abductive inference*, a $15M MURI project to devise learning and inference algorithms for finding the best explanation for massive, noisy, incomplete, and multimodal evidence – led by UW

CSE, and involving CMU, MIT, Oregon State, Rochester, USC, and UT Austin; *Personalized treatment of acute myeloid leukemia*. with UW Hematology, UW Medicine, and the Fred Hutchinson Cancer Research Center; and *Statistical analysis of the 4000-year-old Indus script*, a project with the Tata Institute of Fundamental Research (Mumbai, India) and the Institute for Mathematical Sciences (Chennai, India) to uncover statistical patterns and linguistic structure in the undeciphered Indus script (results published in *Science* and *PNAS*).

Section IV: Future Directions

The department is at both an exciting and a challenging place. We have done extremely well in faculty recruiting, in graduate recruiting, in graduate production, and in research impact over the last decade. It is clear (to us anyway) that our only significant competition for faculty and graduate students is the top four: MIT, CMU, Berkeley, and Stanford. We lose a few graduate students each year to other schools, such as Princeton, Cornell, and Illinois, but those numbers are in the noise. We almost never lose faculty candidates to anyone except the top four, and in fact, we have 5 faculty members who left top-four departments to join us (2 from Berkeley, 2 from CMU, and 1 from MIT). On the other hand, it's not clear that we are recognized as being at that place. Our U.S. News ranking is 7th, behind Cornell and Illinois. And our NRC ranking is a disaster (top 30?) and is meaningless, because the data is fundamentally wrong – due primarily to the UW Graduate School's misunderstanding of the guidelines for faculty counting, which led to a hugely inflated faculty list (we're shown with 91 total faculty!), and due to the NRC's own data collection that led to errors for several important measures (e.g., our awards/faculty are off by a factor of 10, even ignoring the over counting of faculty).

A: The Seattle opportunity ecosystem

Our department exists in two powerful ecosystems from which we benefit, and which provide potential for strategic initiatives. First is the existence of a technology ecosystem in the Seattle area. The technology ecosystem includes Microsoft (especially Microsoft Research), Intel Research Seattle, Google Seattle and Kirkland, Amazon.com, Adobe, RealNetworks, and numerous small high-tech companies. Microsoft Research has the most CSE interaction with lots of joint work; nearly 30 MSR researchers have CSE Affiliate Faculty appointments, and many of them co-supervise students and teach or co-teach seminars or courses. Many of our graduate students do MSR internships and several faculty have spent summers or sabbaticals. We also have very close ties with Intel Research Seattle (IRS) – one of three Intel university "lablets" -- which is run by one of our faculty members on a three-year rotating basis. Current IRS lab director is Dieter Fox; former directors include Gaetano Borriello, James Landay, and David Wetherall, all of whom still maintain technical ties to the lab. Other CSE faculty consult for IRS as well, and seven IRS researchers have Affiliate Faculty appointments in CSE. Google Seattle is run by our former faculty member Brian Bershad and is a target for faculty sabbaticals and student internships.

A subset of the technology ecosystem includes over 150 games and interactive media companies, including Microsoft, Nintendo of America, Bungie, Big Fish Games, Humongous, Sony Interactive Games, and Wild Tangent. Games giant EA Sports is in Vancouver, B.C.

The second powerful ecosystem in the Seattle area includes health care, global health, and developing world technology. The UW School of Medicine (SOM) is the number one primary care medical school in the country and provides enormous opportunity for collaboration. Last year we made our first joint hire with the SOM – Su-In Lee has a joint appointment with Genome Science (we have several adjunct faculty members in that department as well). Yoky Matsuoka has been collaborating with hand surgeons, neurosurgeons, etc. UW is tied to other local hospitals and medical research centers, including Children's Hospital and the Fred Hutchinson Cancer Research Center; we have ongoing collaborations with both, e.g., Linda Shapiro is using computer vision to identify craniofacial conditions for children. In the global health area is the UW Department of Global Health and the Institute for Health Metrics and Evaluation (IHME), run by Chris Murray, who was brought to UW from Harvard with his group by a $100M donation from Bill Gates. The Gates Foundation is obviously a huge force in this area. Path is a nonprofit organization creating health technologies (such as single-use needles, vaccines that time out, etc.); Richard Anderson spent last year on sabbatical at Path and is half time this year. The Grameen Foundation has a Seattle presence as well. The Institute for Systems Biology, founded by former UW professor and genomics pioneer Leroy Hood, combines biologists and technologists, and is targeting personalized medicine. And there is much much more.

B: Ongoing and potential strategic initiatives

The ecosystems described above present significant opportunities. Over the last 5 years we have thought seriously about strategic research initiatives that we could take within the department, within the university, or across universities. These initiatives are focused around our strengths, our opportunities, and areas that we believe are important for us and the future. Following is a list of some of the initiatives that are either underway or that we are considering:

1. HCI. James Landay has created an alliance of faculty and students across campus interested in human-computer interaction, called DUB ("Design, Use, Build"). Currently affiliated departments are CSE, Human-Centered Design and Engineering (HCDE – formerly called Technical Communications), the iSchool, Biomedical Informatics, Urban Planning, Digital Arts, and Art. The result of the creation of DuB is a huge change in the HCI environment at UW and its national position. In a matter of only a few years, UW has become a dominant force in HCI (e.g., at the CHI conference) and clearly one of the top 3 departments nationally (the others are CMU and Georgia Tech). Other UW departments have jumped on the bandwagon and have hired top-tier junior faculty in this area, including Jake Wobbrock (iSchool), Andrew Ko (iSchool), and Julie Kientz (iSchool and HCDE), all who collaborate closely with CSE. A cross-department IGERT proposal in this area has recently been submitted.

2. Computer Engineering. CSE took over its computer engineering degree program and responsibilities in 1989, moving to the College of Engineering as part of that change. While we received positions as part of the move, those positions were not necessarily targeted at hiring in computer engineering. The result is that we are "light" on computer engineering faculty. At the same time, the EE department has made strong hires in CE-related areas, and we felt that we could benefit from closer collaboration with EE in general. In 2006, with the arrival of the new Dean of Engineering, Matt O'Donnell, we proposed a joint initiative in computer engineering between CSE and EE. The ExCEL ("Experimental Computer Engineering Lab") initiative was simply a plan to hire

6 joint faculty along the technical border between the two departments in computer engineering, very broadly defined. ExCEL was to be funded with 2 positions from each department and 2 from the dean (each position costing each 1/3 of a position). At this point we have two ExCEL faculty currently on board – Shwetak Patel (HCI, ubicomp, sensors) and Georg Seelig (synthetic biology), while the third hire, Josh Smith (wireless sensors, robotic sensors), will join us in winter 2011. ExCEL hiring is on hold this year in the wake of the budget situation; we hope to resume when more hiring resources become available. However, ExCEL has already had technical impact and has helped to bring the departments closer together.

3. Neural Engineering. Exciting work is happening at the boundaries of neural science, computer science, and engineering, and UW has strengths in all of these areas. Yoky Matsuoka (CSE) and Tom Daniel (Biology) are co-leaders of an NSF ERC proposal in neural engineering. Raj Rao and Emo Todorov, and others in our department are involved as well. The center includes people from across campus, including EE, Biology, BioEngineering, Physiology and Biophysics, Neurology, Neursurgery, Mechanical Engineering, etc., as well as partners in industry and other universities. The NSF site visit was held on September 29th and went extremely well. The final decision should be known before the 10-year review visit occurs. We are very optimistic, but in any case, there is enormous momentum in the university behind this effort, and that momentum is likely to produce results independent of individual funding proposals.

4. Games for Education. The department has traditionally had strengths in animation, particularly animation research by Zoran Popovic, and we offer a senior undergraduate capstone course sequence in computer animation (which involves students in CSE, Art, Music, Design, etc.), taught by Barbara Mones. While we've wanted to engage the local games community, doing so has been difficult; most games companies are small and focused on current products rather than future technology. More recently, Zoran Popovic, in collaboration with biochemist David Baker and educational experts in the LIFE (Learning in Informal and Formal Environments) Center, has been working on using games both for education and the advancement of science. Most notable is Fold-It, an on-line protein folding game for scientific discovery that has hundreds of thousands of players and has received press in the New York Times, Wired, the Economist, and others. Popovic's early-math learning game, Refraction, recently won a Grand Prize in the Disney Learning Challenge. Popovic is setting up a Center for Games for Education, funded by a major grant from DARPA.

5. Machine Learning. Several years ago, CSE and Statistics tried to create a joint data mining center with support from the Washington Research Foundation. The effort failed because the director being recruited could not relocate in the end. Since that time, the importance of machine learning across science and engineering has increased enormously. Within the department, we have recently hired new faculty in applied ML (Luke Zettlemoyer and Su-In Lee), and we have many "old faculty" applying ML (including Dan Weld, Oren Etzioni, and James Fogarty), but our only core ML person is Pedro Domingos. We believe that there are multiple opportunities in this area. One would be joint hires with statistics. The statistics department is extremely interested in this possibility, but finding positions during this budget crisis is challenging. However, we believe that there is an opportunity to create a broad cross-campus effort in data mining and machine learning – using the "DUB model" established for HCI. Pedro Domingos and Dan Weld recently held the first meeting of the UW-ML group, which was attended by 50 people, and there are 110 on the mailing list, distributed across five

UW colleges. We note that the UW has two highly ranked stats departments: statistics (College of Arts and Sciences) and biostatistics (School of Public Health).

6. E-science. The UW and the State of Washington have recognized the transformational impact of data-intensive research in the sciences. This includes storing, querying, processing, and mining huge amounts of data produced as a result of simulation and sensors. The UW eScience Institute was founded to provide both research and infrastructure for the campus. Ed Lazowska acts as Interim Director. The institute received funds to hire two types of people: researchers who can bring expertise to scientists across the university who do eScience, and researchers who advance the state of the art in eScience areas. Research Scientist Bill Howe, who works on management of large-scale complex scientific data, is attached to our department and is funded by the eScience institute; he is collaborating with faculty in the department, such as Madga Balazinska, on cloud computing support for scientific data analysis. The HCDE department recently hired as a faculty member Cecilia Aragon, who works in HCI and visualization for eScience; she is an adjunct in our department. We also collaborate with Simon Kahan, a former PhD of ours, who worked for Cray for many years on scientific computing; Simon is currently employed by PNNL (Pacific Northwest National Labs in Eastern Washington) but lives in our department. Preston Briggs, a Rice PhD and also former Cray employee, will also be taking a similar position at PNNL and working in our building

7. Technology for the Developing World. As previous noted, there is a lot of activity around developing world technology (and health care in particular) in the Seattle area, and there are a number of projects in CSE as well. One major effort was by our Ph.D. student Tapan, who pioneered the use of cell phone technology in support of micro-finance loans by illiterate populations in India. This year, Ph.D. student Yaw Anokwa and a team of other CSE grad students won the Pizzigati Prize for Software in the Public Interest for their work with Gaetano Borriello in the development of Open Data Kit – Android-based software that turns cell phones into data collection devices that are linked to cloud-based services. Borriello and Richard Anderson (on sabbatical at Path for the past year) are co-leaders of Change, a UW organization on ICTD that includes faculty from the iSchool, HCDE, and CSE. While there are a number of small projects, there is potential for a large future effort in this area in conjunction with some of Seattle's major players.

8. Computational Biology and Synthetic Biology. CSE faculty members Larry Ruzzo and Martin Tompa have worked in the area of computational biology for many years. With Zoran Popovic's work with biochemist David Baker on the Fold-it game (which led to a publication in *Nature* this past August), with the hires of new faculty members Su-In Lee (machine learning for computational biology) and Georg Seelig (synthetic biology), we now have a larger core of biology-oriented faculty. For this reason, we are trying to create more of a presence for the collaborative research that is already going on in the area with departments such as Genome Sciences, Biological Structure, EE, Biochemistry, and BioEngineering. Since 2000 we have been part of an interdisciplinary Ph.D. program in Computational Molecular Biology that involves ten departments as well as the Fred Hutchinson Cancer Research Center; Martin Tompa is currently Program Director. There is also a comp bio symposium held a few times a year, usually attended by 30 to 50 people. But more could be done to increase our visibility in this area.

At the highest level, we are (finally) beginning to reap the benefits of being part of a major research university. These initiatives reach out across campus and create research entities that facilitate new

research and educational collaborations. The success of DUB in HCI has made it a role model for many other initiatives. In the current budget climate, departments are highly motivated to seek cross-department collaboration as an alternative to internal growth, and the result so far is promising given the general faculty quality at the top departments at UW.

C: Challenges

The department faces a number of challenges in the future, some more and some less severe. We mention a few of them here.

1. Financial. The UW budget cuts have been severe. As noted, we project that by 2013 our state budget line will have been slashed by $2M a year. This has prevented our planned growth of educational programs at all levels and removed the new faculty lines planned to support it. We are currently rejecting over 50% of the applicants to our undergraduate program and demand for our classes is extremely high. In addition, our staff members are under tremendous pressure due to the loss of staff and the corresponding increase in workload per person. Our faculty support staff,in particular, are at a breaking point.

2. Faculty Salaries. We have gone two years without raises with no end in sight. While our assistant and associate professors are close to the national norms, our mean salary for full professors is $17K below the mean for departments ranked 1 – 12 and $24K below departments ranked 13 – 24, as shown in the Taulbee survey. As noted, Google has already recruited three senior faculty and is trying for more.

3. Organization vs. culture. The department has grown significantly in both size and complexity over the last decade, and the growth has stressed our consensus-based decision making and management process. When (and if) more growth comes in the future, it's unclear whether a new structure might be required. We are looking for better ways to manage ourselves and our decision making while still maintaining our culture, which is important to faculty, students, and staff.

4. Space. After seven years the Allen Center is completely full. Lack of space will be inhibiting future growth and success. Even in shrinking state budgets, we are seeing exciting large-scale initiatives that will be difficult to support without appropriate on-campus people and research space.

D. Vision for the future

Despite our challenges, we believe that the department is doing extremely well; we are producing high-quality research and are graduating students that are highly successful in both academia and industry. Given where we are, our major challenge is how to make a significant move forward on a national level. We want to be recognized as being among the very top departments nationally ("top 5" for example). We want to continue to have impact and we want that impact to be broad, i.e., both in core computer science and in attacking national challenges such as energy, healthcare, security, and education. And we want to grow and become leaders in new areas.

PART B: Unit-Defined Questions

As part of the review process we defined three CSE-specific questions:

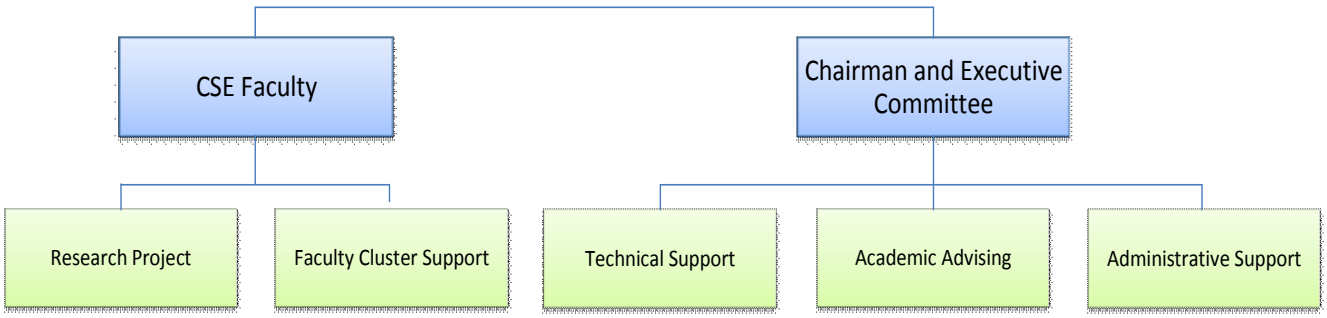
1. How are we doing in our missions of research and education on a national scale?
2. Are we playing an appropriate role and having impact on the campus and in the region?
3. How do we grow and improve in the most effective way in the future?

We provided discussion and data relevant to these three questions in Sections III, II, and IV, respectively.

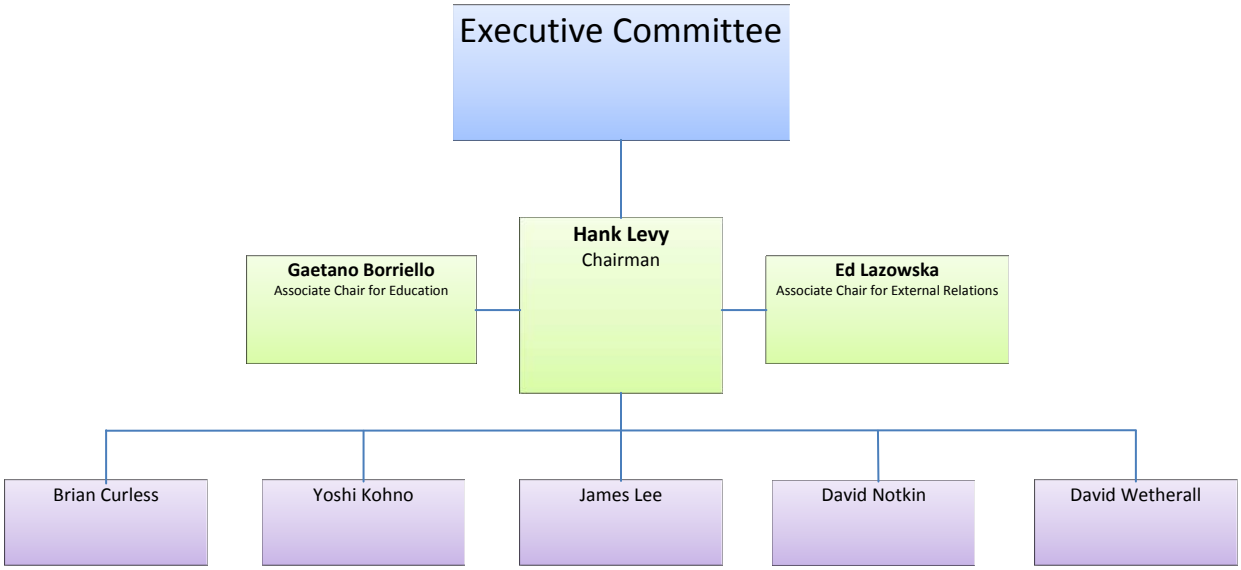
PART C: Appendices

Appendix A: Organizational Charts

Department of Computer Science & Engineering Organizational Chart



Department of Computer Science & Engineering
Executive Committee



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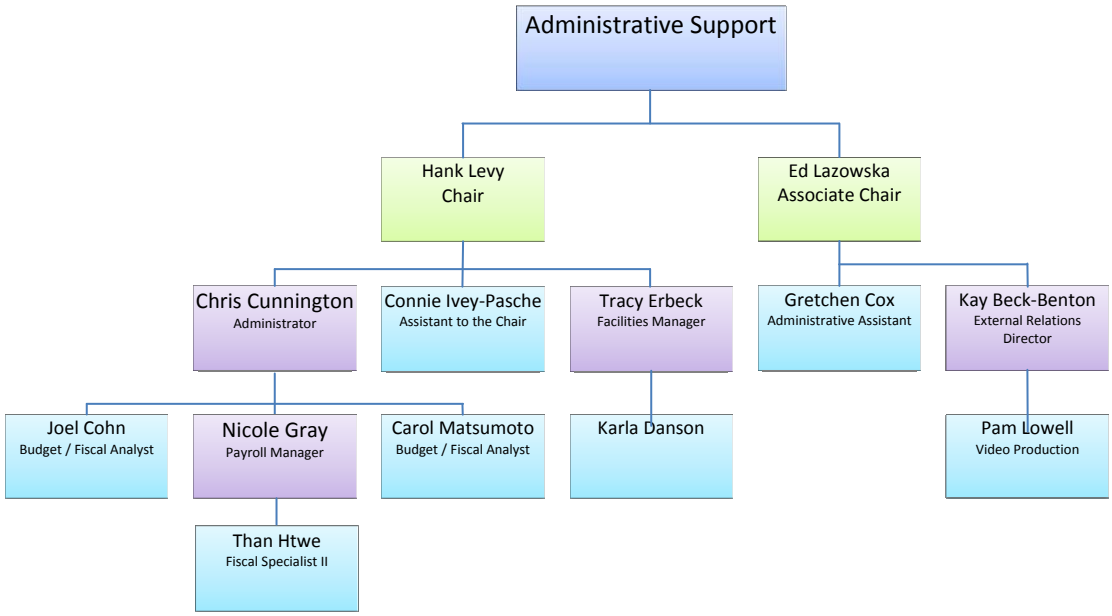
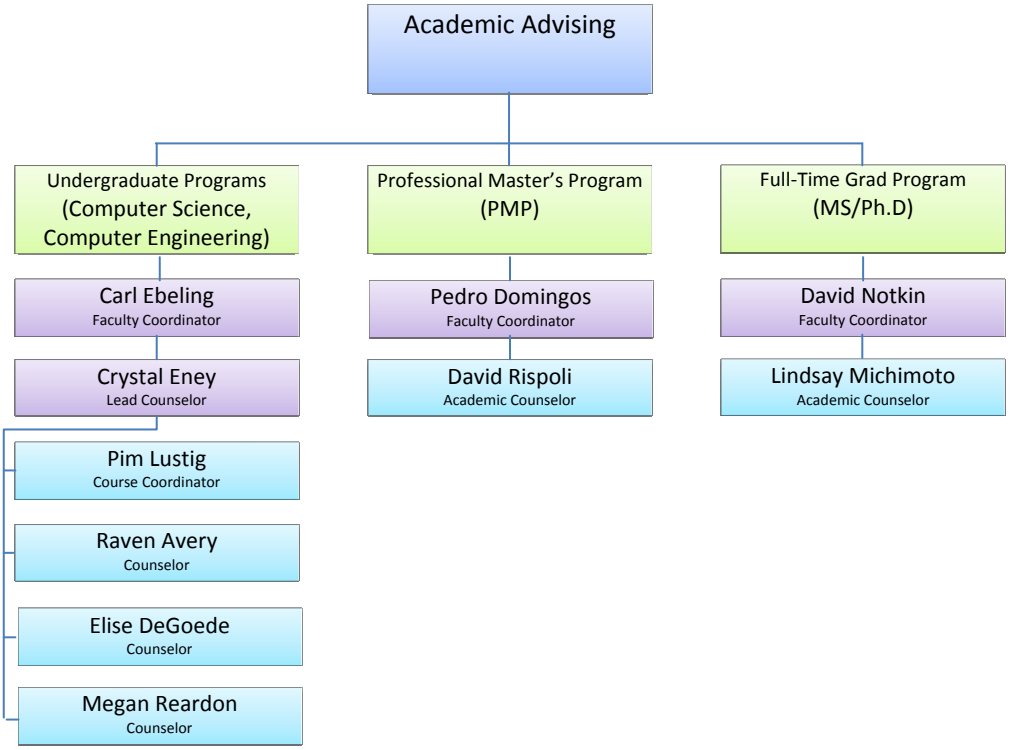
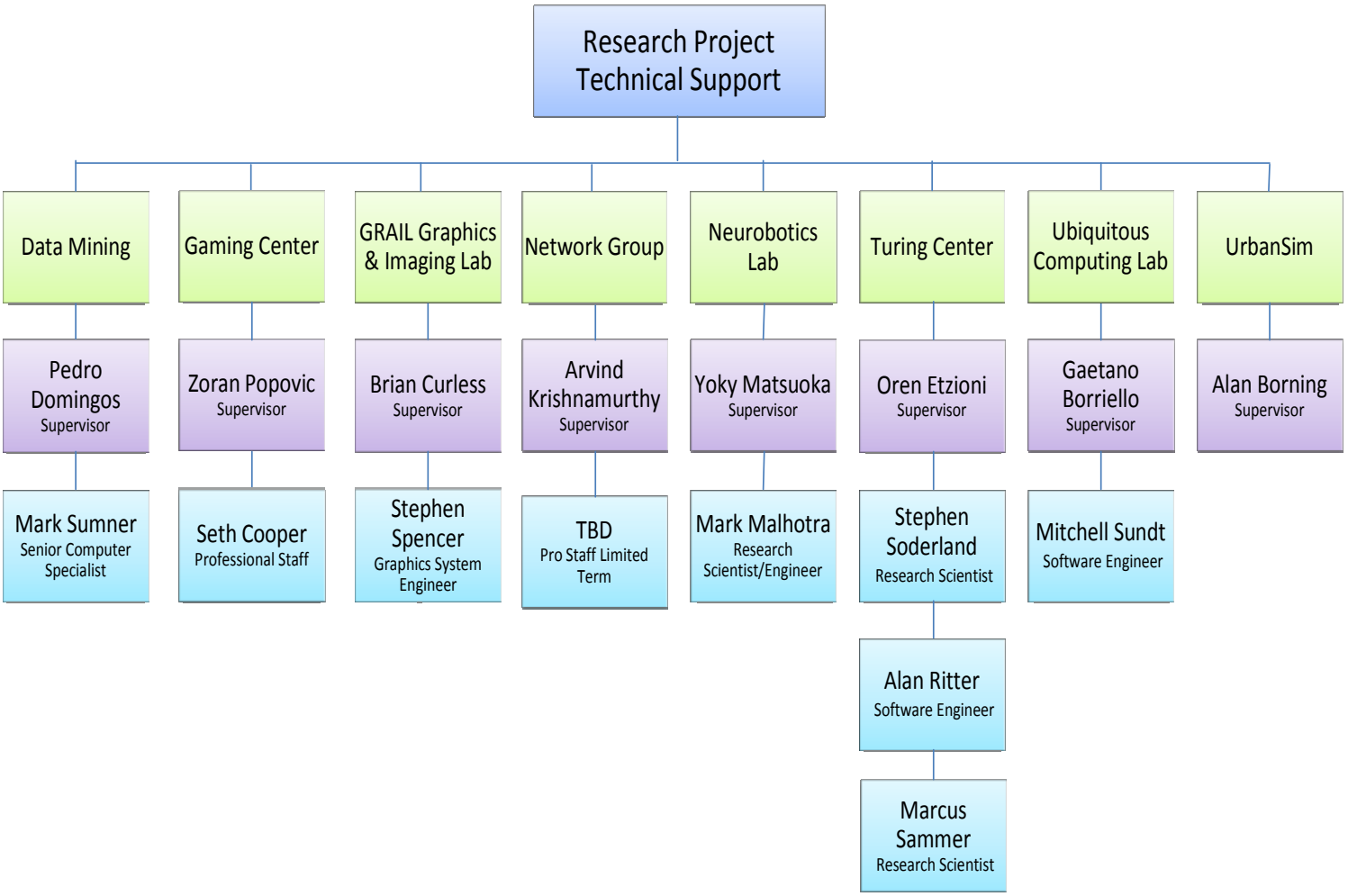
Administrative Support



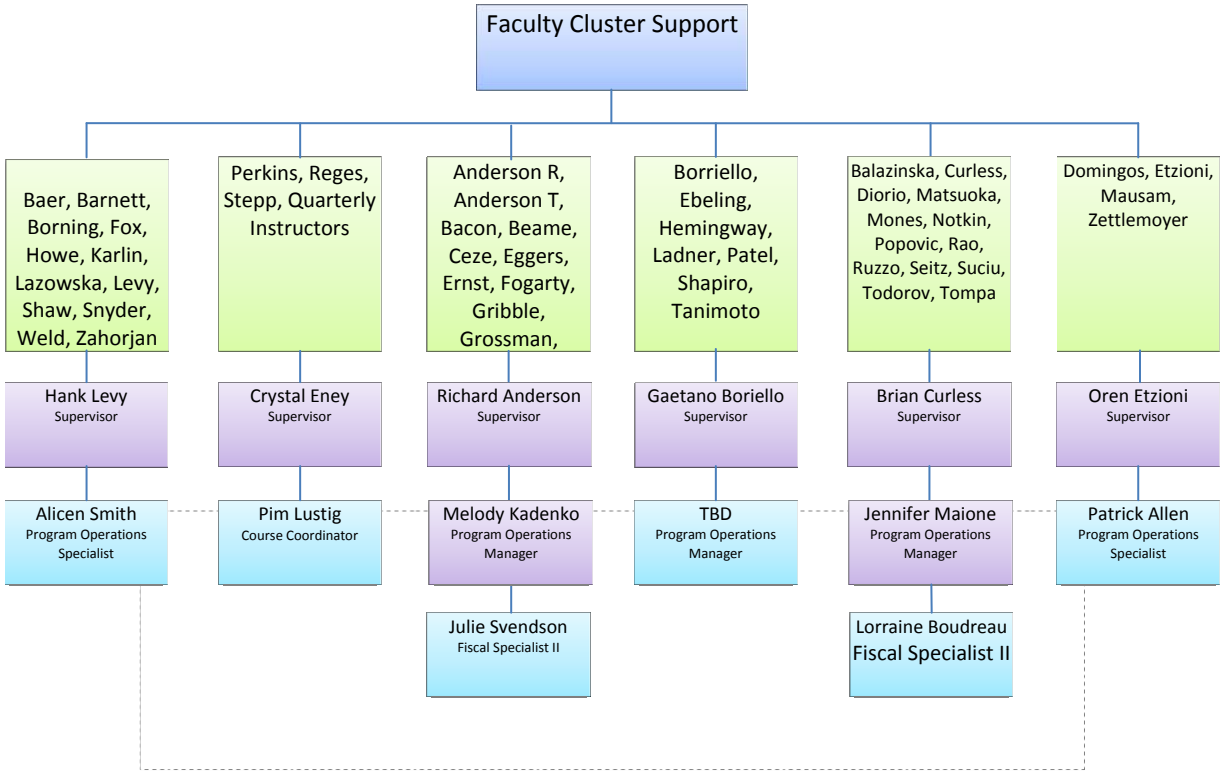
Department of Computer Science & Engineering
Academic Advising



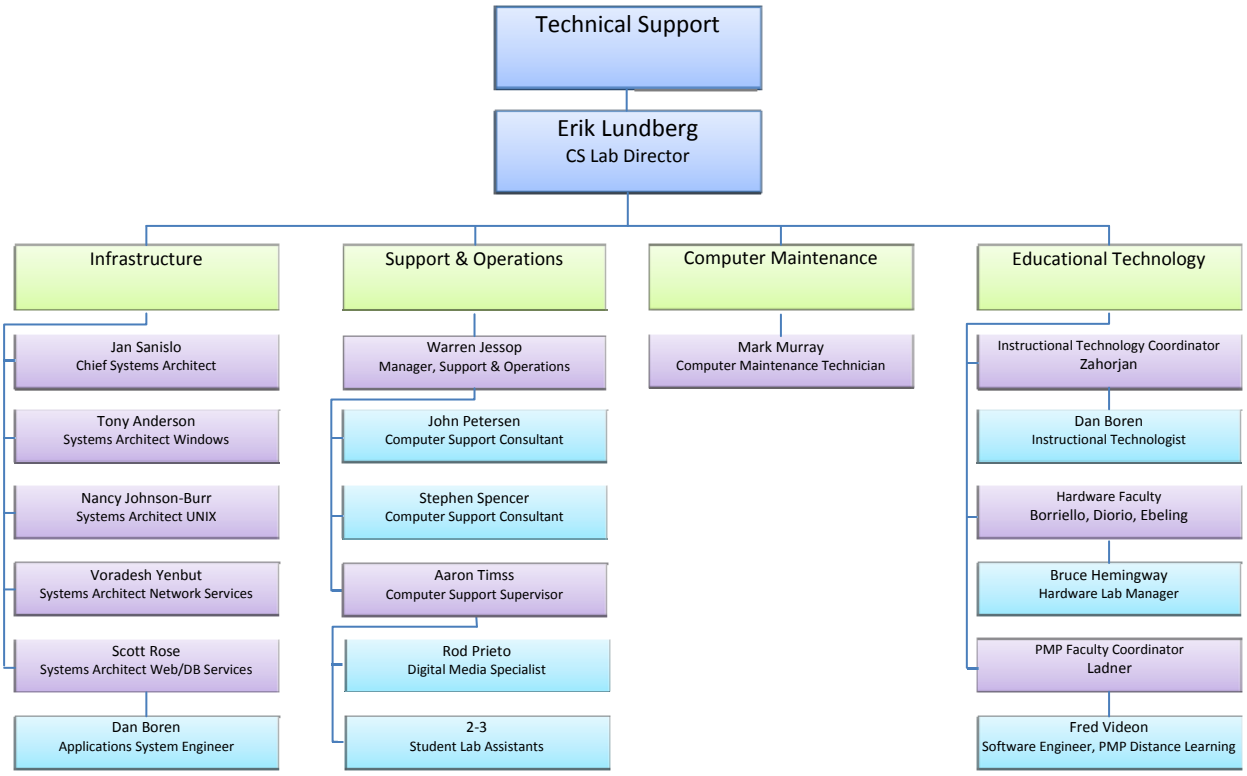
Department of Computer Science & Engineering
Research Technical Support



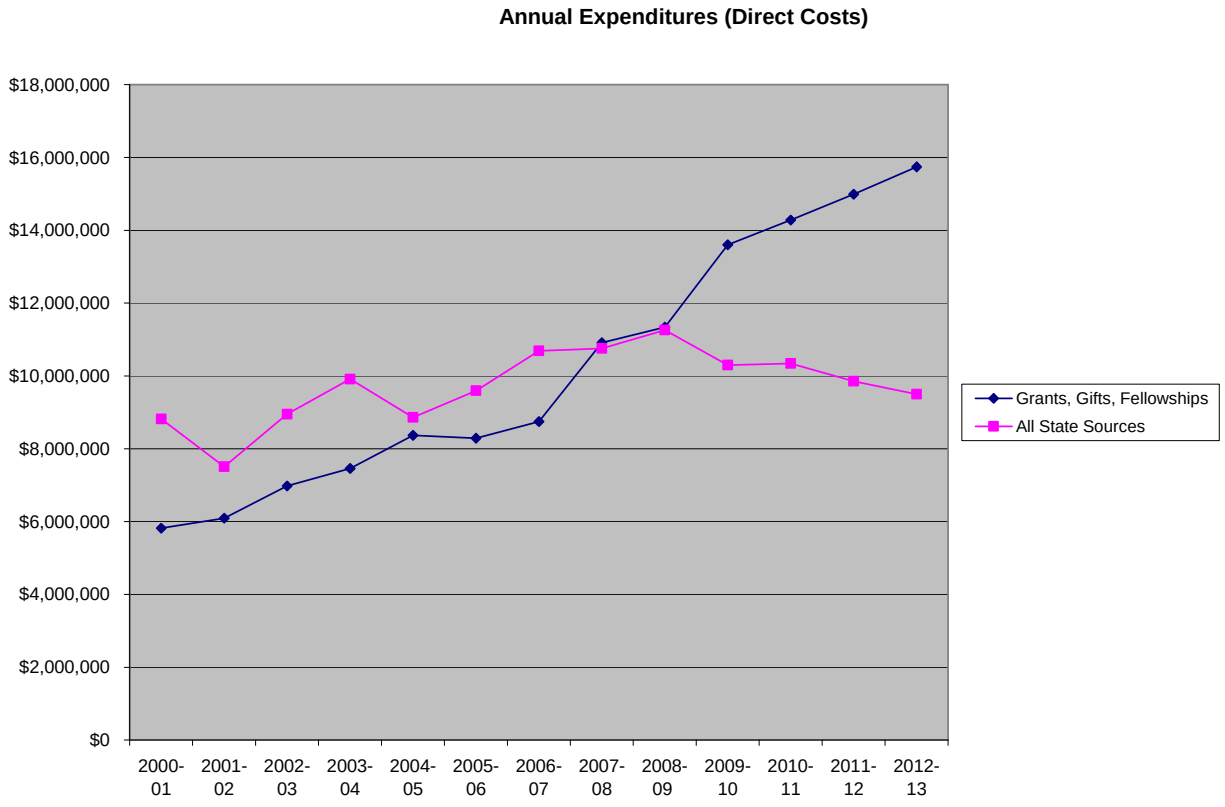
Department of Computer Science & Engineering
Faculty Cluster Support



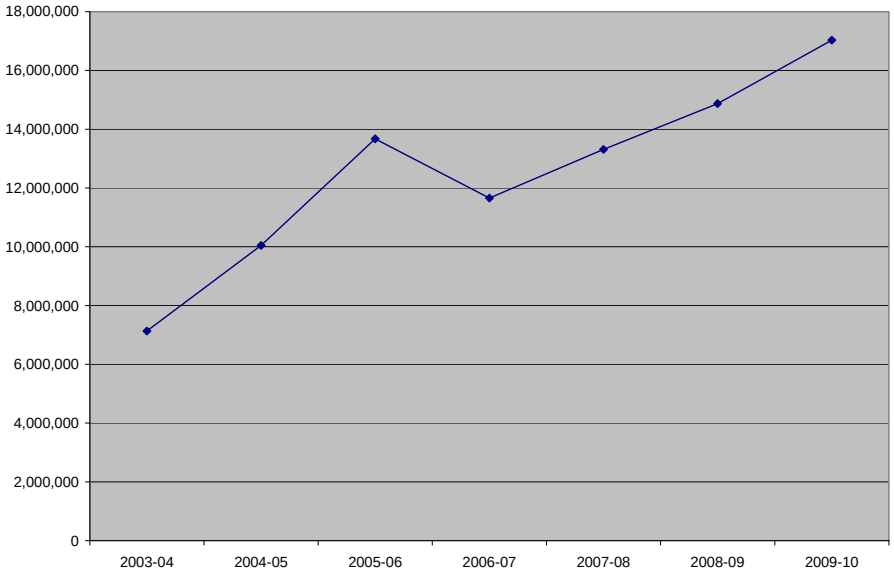
Department of Computer Science & Engineering
Technical Support



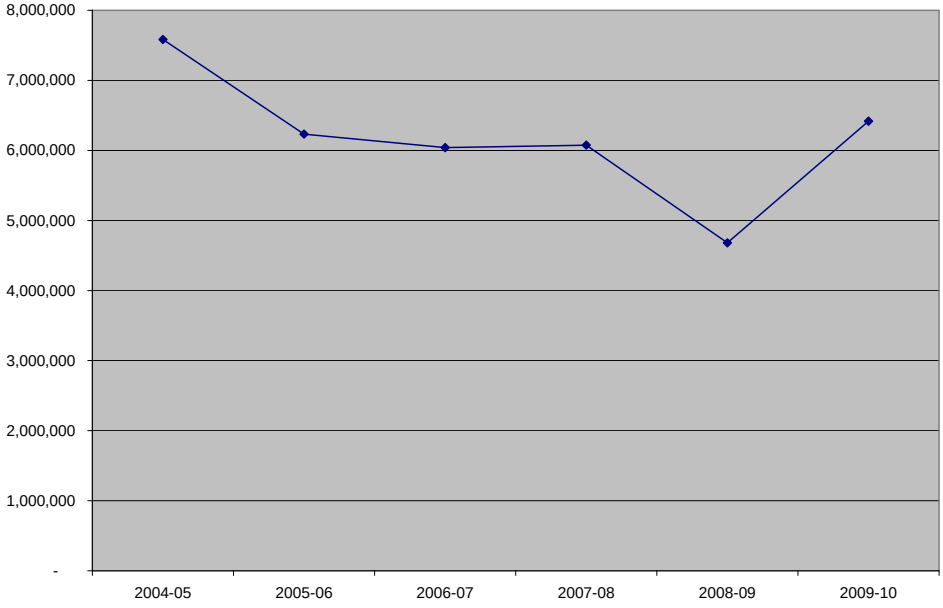
Appendix B: Budget Summary



Grant Awards



Gifts Received



Appendix C: Faculty Summary

TENURE-TRACK FACULTY	RANK	APPOINTMENT TYPE	AFFILIATIONS
Richard Anderson	Professor	9 Month	N/A
Tom Anderson	Professor	9 Month	N/A
Magda Balazinska	Assistant Professor	9 Month	N/A
Paul Beame	Professor	9 Month	N/A
Alan Borning	Professor	9 Month	I-School
Gaetano Borriello	Professor	9 Month	EE, HCDE, I-School
Luis Ceze	Associate Professor	9 Month	N/A
Brian Curless	Professor	9 Month	N/A
Pedro Domingos	Associate Professor	9 Month	N/A
Carl Ebeling	Professor	9 Month	EE
Susan Eggers	Professor	9 Month	N/A
Michael Ernst	Associate Professor	9 Month	N/A
Oren Etzioni	Professor	9 Month	Linguistics
James Fogarty	Assistant Professor	9 Month	N/A
Dieter Fox	Associate Professor	9 Month	EE
Steve Gribble	Associate Professor	9 Month	N/A
Dan Grossman	Associate Professor	9 Month	N/A
Anna Karlin	Professor	9 Month	N/A
Yoshi Kohno	Assistant Professor	9 Month	N/A
Richard Ladner	Professor	9 Month	EE, Linguistics
James Landay	Professor	9 Month	HCDE, I-School
Ed Lazowska	Professor	9 Month	N/A
James Lee	Assistant Professor	9 Month	N/A
Su-In Lee	Assistant Professor	9 Month	Joint Genome Sci
Hank Levy	Professor	9 Month	N/A
Yoky Matsuoka	Associate Professor	9 Month	BioE, EE, Mech Eng
David Notkin	Professor	9 Month	N/A
Mark Oskin	Associate Professor	9 Month	EE
Shwetak Patel	Assistant Professor	9 Month	Joint EE
Zoran Popovic	Associate Professor	9 Month	N/A
Anup Rao	Assistant Professor	9 Month	N/A
Larry Ruzzo	Professor	9 Month	Genome Sciences
Georg Seelig	Assistant Professor	9 Month	Joint EE, Adj. BioE
Steve Seitz	Professor	9 Month	N/A
Linda Shapiro	Professor	9 Month	Joint EE, Adj Med Ed
Dan Suciu	Professor	9 Month	N/A
Steven Tanimoto	Professor	9 Month	EE
Emo Todorov	Associate Professor	9 Month	Joint Applied Math
Martin Tompa	Professor	9 Month	Genome Sciences
Dan Weld	Professor	9 Month	N/A
David Wetherall	Associate Professor	9 Month	N/A
John Zahorjan	Professor	9 Month	N/A
Luke Zettlemoyer	Assistant Professor	9 Month	N/A

LECTURERS			
Bruce Hemingway	Lecturer	12 Month	N/A
Barbara Mones	Senior Lecturer	9 Month	N/A
Hal Perkins	Senior Lecturer	9 Month	N/A
Stuart Reges	Principal Lecturer	9 Month	N/A
Marty Stepp	Lecturer	9 Month	N/A
RESEARCH FACULTY			
Dave Bacon	Research Assistant	12 Month	N/A
Arvind Krishnamurthy	Research Associate	12 Month	N/A
Mausam	Research Assistant	12 Month	N/A
EMERITUS/DEPARTED			
Jean Loup Baer	Emeritus		
Brian Bershad	to Google		
Craig Chambers	to Google		
Chris Diorio	Founder/CTO of Impinj		
Venkat Guruswami	to CMU		
Alon Halevy	to Google		
Henry Kautz	to U Rochester		
Larry Snyder	Emeritus		

Faculty 2-page CVs can be found at: http://norfolk.cs.washington.edu/drcv

Appendix D

EXISTING PROGRAM REVIEW: HEC BOARD SUMMARY

Unit authorized to offer degrees:	Department of Computer Science & Engineering
College:	College of Engineering
Degree Titles:	Bachelor of Science in Computer Science (offered through the College of Arts & Sciences) Bachelor of Science in Computer Engineering (offered through the College of Engineering) Master of Science (one degree title covers our traditional full-time program, the Combined BS/MS Degree Program and also our part-time evening/distance Professional Master's Program) Doctor of Philosophy
Year of last review:	January 2000
Date Submitted:	November 16, 2010

Number of instructional faculty, students enrolled, and degrees granted over last three years (Autumn-Summer)

		2007-08	2008-09	2009-10
FTE: Tenure-track faculty		40.67	43.17	43.67
Research-track faculty		3	3	3
Instructors		4.5	4.5	4.5
Total		48.17	50.67	51.17
FTE graduate teaching assistants		100	108	107
Degree Program	Bachelor of Science			
Headcount of enrolled students		489	506	533
Number of degrees granted		146	148	171
Degree Program	Combined BS/MS Degree Program			
Headcount of enrolled students		N/A	5	18
Number of degrees granted		N/A	3	14
Degree Program	Professional Master's Program			
Headcount of enrolled students		129	127	132
Number of degrees granted		43	52	43
Degree Program	Doctor of Philosophy			
Headcount of enrolled students		156	154	161
Number of degrees granted	Ph.D	19	19	23
	MS	23	24	21