Strategic Plan

Computer Science Department
Stanford University

October 2006 (revised version)

Executive Summary

The Stanford Computer Science (CS) Department continues to lead the world in computer science research and education. Throughout the past four decades, the Stanford CS Department has influenced society at levels that remain without parallel among academic institutions. Its spin-offs are among the most successful corporate ventures in the world, and many of the leaders in the academic and corporate research world are graduates of the Stanford CS Department.

With this strategic plan, the Stanford CS Department lays out its direction for the next two decades of research and education. The plan is the result of a unified vision, by which CS is becoming *pervasive* in all of society. This important development creates new challenges and opportunities for CS research and education.

The three pillars of pervasive computing are as follows:

Pervasive computer systems: Within two decades, computers will routinely collect terabytes of data person per day. A majority of our business and personal decisions will rely on pervasive data. To create the capability to collect and interpret such massive amounts of data, we will build computer systems of unprecedented scale and connectivity. And we will invent new, more scalable techniques for extracting information from massive data streams. To facilitate this transformation, the Stanford CS Department has to strengthen its faculty in machine learning, distributed databases, software engineering, privacy, and security.

Physical and virtual environments: Within two decades, we will embed sensors into a majority of our physical spaces (cars, buildings, urban areas). These sensors will enable us to gather detailed models of physical spaces and activities, and to seamlessly integrate these models into virtual worlds. As a result, we will overcome critical boundaries that presently constrain people-to-people and people-to-environment interactions. We will be able to carry out meaningful long-term interactions with others regardless of where they are, what language they speak, and so on. To enable this transformation, the Stanford CS Department has to increase its presence in sensor networks, computer vision, natural language, embedded systems, computer graphics, creative design, and human-computer interaction.

Computational foundations for other academic disciplines: Within two decades, about a dozen non-CS disciplines in science and engineering will adopt CS as a core methodology. These disciplines will rely on CS to provide computational methods for problem solving

and as a foundational framework in which key concepts can be stated formally. And they will rely on CS to harvest scientific information from massive new datasets. This dialogue between CS and other scientific discipline will fundamentally transform science and engineering. The Stanford CS Department has to help Stanford University to position itself as a global leader in this new array of CS-enabled disciplines, through a plurality of activities in faculty recruiting, research, and education.

With respect to the present state of the Stanford CS Department, this strategic plan committee finds that moderate adjustments are required to prepare the department for the challenges that arise out of this vision. This strategic plan identifies four primary changes pertinent to the future leadership role of the Stanford CS Department.

Faculty hiring: We recommend that the Stanford Computer Science Department strengthen its research in nearly all aspects of pervasive computing, as laid out in more detail in this document. As pervasive computing is inherently interdisciplinary, the department needs to continue to form alliances with other departments. It needs to promote joint hires and continue to attract exceptional students whose interests cut across multiple disciplines. At the same time, the department needs to retain its identity as a CS department and continue to strengthen the core of computer science.

Interdisciplinary initiatives: We recommend the Stanford CS department create "light-weight" mechanisms to facilitate interdisciplinary research and teaching, without the creation of additional administrative structures. This can be achieved by supporting interdisciplinary laboratories in which faculty from multiple areas share resources. The department should also provide moderate incentives for faculty and students to engage in high-risk interdisciplinary research and education, and seed-start activities in areas that outside the boundary of existing activities.

Educational reform: We recommend that the department update its educational program to meet the requirements of a multi-disciplinary workforce in the pervasive computing age. The educational programs need to provide additional flexibility for students to pursue non-traditional, interdisciplinary education. Especially at the undergraduate level, we recommend the formation of a smaller core, augmented with tracks that provide students with freedom to specialize in several different areas of computing. We also recommend that the department strengthen the communication and collaboration skills of its graduates, and that the department take active steps towards reducing its gender and minority imbalance.

Research funding. As DoD funding for CS research is in a Nation-wide decline, we recommend that the department actively pursue new funding models. For example, the department could increasingly draw on Government and foundational initiatives in the interdisciplinary life sciences. The department should also consider growing its corporate supporter base, through strengthening its existing corporate affiliates programs.

This plan describes in more detail the findings of the strategic plan committee, and the reasoning behind these recommendations.

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1. Computer Science: Past, Present, and Future

The field of computer science started some fifty years ago, with the recognition that computing on a digital machine was distinctly different from other engineering and scientific disciplines. Early computer science research was often inward-looking, treating computers as machines for number crunching or managing data. The 1990s fundamentally changed the field. Through important innovations such as the Internet, computers have opened up new ways for people to interact. The enormous reduction of costs per computer cycle has made it possible to embed computers everywhere in our environments, seamlessly blending physical and computational worlds.

These developments are just the beginning of a far more fundamental transformation of society. Within the next two decades, computing will become pervasive in many aspects of our lives:

- By 2026, the majority of our decisions will be based on data mediated by massive computer systems. We will routinely collect terabytes of data per person per day and use massive new machine learning techniques to discover new patterns. The data will be multimodal; it will include video, text, speech, personal activity data, and it will be cross-linked to other multi-structured databases such as stock markets, weather patterns, traffic information, and so on. Managing this data, and extracting useful information while preserving our privacy, will become one of the major challenges for CS in the pervasive computing age. *These developments require new expertise in machine learning, software engineering, databases, privacy, security, architectures, and related disciplines.*

- By 2026, many individuals in the developed world will own on the order of 10^4 CPUs. Because people cannot operate 10^4 keyboards, these computers will be equipped with sensors and actuators through which they can affect our environments. Most computers of the future will be low-cost, embedded, and massively distributed. They will be networked, and they will be physically embedded in our environments. These pervasive physical sensor networks will enable us to monitor in minute detail our own physical activities, and they will provide a seamless bridge to the virtual world. *These developments call for new expertise in algorithms, machine learning, networking, robotics, computer vision, computational geometry, and related disciplines.*

- By 2026, we will spend a significant fraction of our time in virtual worlds. Present-day examples of this new trend include chat rooms, instant messaging, BLOGs, virtual classrooms, online gaming, and interactive movies. In the future, teaching will increasingly rely on virtual classrooms, enabling students and teachers to interact over long distances. In our business interactions, we will use virtual worlds to gather information and interact with each other. And in our free time, we will explore remote physical places through virtual interfaces, and engage in virtual games and interactive movies with people far away. Virtual worlds will fundamentally alter the way we interact. And some of those digital interactions will seamlessly integrate with physical environments. *These developments call for new expertise in computer graphics, human computer interaction, robotics, natural language, speech, and related disciplines.*

- By 2026, computer science will be pervasive in many other scientific and engineering disciplines. Already, some disciplines rely heavily on core CS to advance their fundamental research. One ongoing revolution is currently taking place in the biological sciences, where CS has made fundamental contributions to many aspects of fundamental biology research. Likewise, CS has also transformed most engineering disciplines. In the next two decades, CS will grow in importance in many other disciplines, such as cognitive psychology, neuroscience, medicine, and economics. With time, CS may influence many less obvious disciplines, such as philosophy, arts, and athletics. This transformation will create enormous opportunities for the field of computer science, whose impact will transcend well beyond its present scope. *These developments call for a new computer science that reaches out to these new CS-enabled disciplines.*

As a result of this transformation, the field of CS will be characterized by enormous growth, predominately in the areas mentioned above.

Already, Computer Science has been recognized as the fastest growing field in all of engineering. According to a recent study by the U.S. Department of Labor Bureau of Labor Statistics, 61% of all engineers needed in industry at the present point are computer specialists. The national demand for computer and software engineers is projected to increase by 45% over a ten-year period (from 2002 to 2012), making CS the fastest growing segment of all of engineering. In April 2006, Money Magazine ranked software engineer the #1 Job, also projecting a 46% increase in the labor pool over the next ten years. It noted that "software engineers are needed in virtually every part of the economy".

In addition to these market-based projections, CS is also gaining in importance in nearly all engineering and science disciplines, and even in the humanities and the arts. Many engineering and science departments across the country are presently hiring faculty trained in computer science, to further progress in their own areas. This has created a need for CS specialists with strong interdisciplinary education and skills, a need which remains largely unfulfilled.

2. Stanford Computer Science Department

2.1 Mission

The research mission of the Stanford Computer Science Department is to lead the world in computer science and engineering research. Building on a forty-year tradition of excellence, the Stanford CS department seeks to engage in cutting-edge research, and to lead society into the new age of pervasive computing. Its mission is to contribute to an array of important open problems that define the society of tomorrow, including quality of life, health, environment, and energy.

The Stanford Computer Science Department seeks to produce tomorrow's leaders in education, research, industry, and public policy. Its goal is to create leaders who will shape the future of society, not just armies of programmers. To lead the field of computer science, CS graduates need to be proficient not just in computer science research. They need to be creative out-of-the-box thinkers. They need to have interdisciplinary skills and an ability to work with others. And they need to communicate effectively and act socially responsibly.

The mission of the Stanford CS Department transcends beyond disciplinary boundaries. The department wishes to enable other academic disciplines through core CS research, and to expand the horizons of the Computer Science discipline by considering the research challenges of other fields. The department's mission entails the education of a new generation of interdisciplinary students who build bridges, and who innovate at the intersection of multiple scientific fields. The Stanford CS Department has always enjoyed a strong interdisciplinary focus on research with high societal impact, in both research and education. It seeks to build on this strength when building new bridges to other scientific and engineering disciplines.

2.2 State of the Department

The Stanford Computer Science Department has 42 affiliated faculty members. Of these, 29 have their only appointment in CS, 11 have joint appointments with other departments, one is a research faculty with a 50% appointment in CS, and one a non-tenure line teaching faculty; two additional tenure-line billets remain unfilled[1]. The department has annual research expenditures totaling $18.5M (2005 data). Throughout its forty-year history, the department has consistently enjoyed a number-one status among peer computer science departments in the US, as determined by various national rankings. This status has often been shared with up to three other institutions: the University of California at Berkeley, Carnegie Mellon University, and the Massachusetts Institute of Technology.

The Stanford CS Department contributes significantly to the overall education in the Stanford School of Engineering. At present, 182 PhD Students are enrolled in computer science at Stanford

[1] The department possesses 34 FTE tenure-line faculty slots. Of those, a total of only 31 billets are associated with the Stanford Computer Science department, according to the School of Engineering (SoE). This discrepancy results from the fact that the SoE count provides special provisions for several faculty members.

(2006 data). The department recruits approximately 35 new PhD students each year, who stay an average of 5.5 years at Stanford. The present enrollment in the MSCS program is approximately 300. About 350 students are declared CS undergraduate majors at any point in time. In the past, these numbers have been subject to fluctuations. Naturally, the number of declared majors peaked in 2001, at the height of the "dot com bubble." In the years that followed, the enrollment decreased to its pre-bubble level in 1997 and has since stabilized. The "bubble-effect" in the enrollment data echoes a Nation-wide trend, yet at many other peer institutions the post-bubble enrollment data is much grimmer than at Stanford. Of general concern, however, is the number of women in computer science, which has slightly decreased at Stanford University even when compared to 1997 figures. The ratio of women has recently fallen below 10% in the department's graduate population, and ethnic minorities remain underrepresented.

Within the Stanford School of Engineering (SoE), the Computer Science Department educates more students than any other department. The introductory courses CS 103A, 103B, 103X, 105, 106A, 106B, 106X, 107, 108 are taken by many non-CS students; some of those courses enjoy the highest enrollment of any classes on Stanford's campus. The Computer Science Department has highest per-instructor teaching load in the School of Engineering (SoE). When including CS lecturer staff, the CS department teaches 1,093 units/FTE, compared to the average 434 in the School of Engineering. That is, CS faculty members teach 2.5 times as many units/FTE than non-CS faculty in the SoE. Even excluding the lecturer staff form this statistic, CS faculty still teach, on average, 50% more units than non-CS faculty in the SoE. These statistics underline the continued popularity of computer science in the early 21st Century, and also emphasize the comparatively high teaching contributions by CS faculty in the Stanford environment.

The Stanford Computer Science Department also enjoys a continued strong industrial impact and support. CS spin-offs include Google, Yahoo!, SUN, Rambus, SGI, MIPS, Cisco, and VmWare. Some of these corporations are among the highest-valued technology corporations in the Nation. Local industry has become a major financial sponsor of research and education in the department. The Stanford Computer Forum, which is the industrial affiliate program of the department, features 55 member companies (2006 data). These statistics attest once again to the impact of the Stanford CS department on the corporate world, and the successful efforts of the department to maintain strong ties to industry.

2.3 Challenges and Opportunities

As noted, the Stanford Computer Science Department has consistently enjoyed a number one ranking among the computer science departments in the U.S. The excellent reputation of the department is remarkable given that it possesses notably fewer faculty than its peer institutions; see Table 1 (estimates).

	Systems	AI	Theory	Total
MIT (CSAIL)	22	31	16	69
UC Berkeley	26	10½	8	44½
CMU	25½	25	18½	69
Stanford	15	9½	6½	31

Table 1: Estimated Faculty sizes and areas in computer science at peer institutions. Here the systems category includes computer architecture, operating systems (OS), programming languages (PL), networking, databases, graphics, and human computer interaction (HCI). Artificial Intelligence (AI) includes machine learning, robotics, computer vision, natural language and speech, logic, knowledge representation, and game theory. Theory includes numerical methods, privacy and security, algorithms, complexity theory, and computational geometry.

As this table suggests, the relatively small size of the computer science faculty at Stanford University has become one of the department's biggest obstacles. This limitation is at the verge of hindering the department from making important adjustments in its research and educational activities, in particular in its pursuit of interdisciplinary research and education. In times of limited faculty growth, one of the key challenges will be to place available faculty billets so as to maximally prepare the department for future leadership in the field. The department should also actively pursue opportunities to make additional hires, whether as part of the university-wide interdisciplinary initiatives, via joint hires with other departments, or by incremental billets intended to bring the size of the department closer to that in peer institutions.

A second challenge arises from a change of the research funding landscape. While in the past, DARPA and other defense-oriented Government agencies have contributed significantly at the basic research level, those funds are now often diverted into more applied (and often classified) research areas, leading to a significant reduction in government funding for academic institutions. According to a recent report[2], "in the past 3 years, DARPA funding for universities has dropped nearly in half," with basic research affected at an even higher degree. This trend runs counter to a recent PITAC report, which in 1999 recommends a doubling of federal funds for basic IT research[3]. Since DARPA was once Stanford's single largest source of research funding, this change has forced the department to diversify its funding base. The diversification comes with new challenges. The increased reliance on application-driven funding sometimes makes it difficult to pursue independent, high-risk research, which is of course vital to the department. Below, this document will state specific recommendations aimed at strengthening the departmental funding base.

A third challenge arises from the continued gender imbalance and an under-representation of minority groups inside the department. For example, only15% of the present undergraduate population is female, whereas 84% is male (2006 data). This is in sharp contrast to the Nation's overall student body, where approximately 57% of all students are females (2004 data[4]). The department should take any effort to adjust its gender and minority balance.

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[2] E.D. Lazowska and D.A. Patterson. *Computing research: a looming crisis.* ACM SIGCOMM Computer Communications Review 35:3, pg 65—68, 2005.

[3] B. Joy, K. Kennedy et al. *Information technology research: investing in our future*. President's Information technology Advisory Committee, Feb. 1999, online at http://www.nitrd.gov/pitac/report

[4] IES National Center for Education Statistics, Digest of Education Statistics, 2005, online at nces.ed.gov.

3. Faculty Hiring and Incentives

		Pervasive Systems	Physical+Virtual Environments	Interdisciplinary CS
Systems	Architecture/OS/PL	+++	++	+
	Software Engineering	+++	++	++
	Networking	++	+++	
	Databases	+++	++	+
	Graphics	+	+++	+
	HCI		+++	++
Artificial Intelligence	Machine Learning	+++	++	+++
	Robotics		+++	
	Vision/Perception		+++	+
	Language/Speech	++	+++	
	Logic and KRR	++	+	+
	Game Theory		++	++
Theory	Numerical methods	+	++	+++
	Privacy / security	+++	++	
	Algorithms	+++	+++	+++
	Comp. Geometry		+++	++

Table 2: Relevance of the core areas in computer science to the three pervasive computing pillars.

3.1 Goals

The primary goal of the faculty hiring plan is to ensure continued leadership as society transitions into the age of pervasive computing. Table 2 relates the three primary thrusts in pervasive computing to the core areas of computer science. From this table and an analysis of the current faculty strengths and weaknesses at Stanford, the hiring plan identifies a number of priority areas.

As we find, many of these areas are multi-disciplinary, and hence are best pursued jointly with other departments on campus. The preferred instrument for identifying suitable faculty candidates is the broad area search because it enables the department to hire opportunistically. This committee advises against specialized searches in that they tend to weaken the applicant pool.

While implementing this pervasive computing vision, it is imperative that the department retain a strong CS core. The goal of hiring cannot be to chase application areas, and disperse the department into a scattered field of areas in the service of other scientific disciplines. Thus, in new faculty hires, the department shall place a strong emphasis on strengthening its core of computer science.

Because of the existing strength of the Stanford CS department, the focus of hiring should be on junior faculty at the assistant professor level. A possible exception arises in the area of computer

vision, which is a strategically important area that has been vacant for several years. Here, the department may consider the appointment of a senior person, to seed-start activities in this field.

Over all of this, the department shall remain open to opportunistic out-of-the-box hires. In the past, many important developments of CS surprised even the most informed experts. Exceptional individuals whose research areas fall outside existing fields and boundaries, and whose work shows high promise for a paradigm shift, should always be given special consideration in the hiring process.

		General	Pervasive Systems (hire 4)	Physical+Virtual Environments (hire 6)	Interdiscipl. CS (hire 5)
Systems	Architecture Operating Systems Progr. Languages	Dally Horowitz Kozyrakis Mitra	Rosenblum Lam Mazieres Aiken Engler	Levis **(hire 1)**	
	Software Engineering	Dill	Cheriton **(hire 1)**	**(hire 1)**	
	Networking	McKeown Prabhakar			
	Databases		Garcia-Molina Widom		
	Graphics			Hanrahan Levoy	Fedkiw
	HCI			Winograd Klemmer **(hire 1)**	
Artificial Intelligence	Machine Learning		**(hire 1)**	Ng **(hire 1)**	Koller Batzoglou **(hire 1)**
	Robotics			Khatib Thrun	
	Vision / Perception			**(hire 1)**	
	Language/Speech			Manning	
	Logic / KRR		Genesereth		
	Game Theory				Shoham
Theory	Numerical methods	Golub			
	Privacy / security		Mitchell Boneh **(hire 1)**	**(hire 1)**	
	Algorithms	Motwani Plotkin Koltun Mannar	**(hire 1)**		Roughgarden **(hire 1)**
	Comp. Geometry			Guibas	Latombe
Others	Biology and others				**(hire 3)**

Table 3: Existing faculty and hiring needs of the Stanford CS Department.

3.2 Priority Hiring Areas

Table 3 lays out the detailed hiring plan for the Stanford Computer Science Department for the next ten years (the color coding is equivalent to the one in Table 2). In accordance with the three main thrusts of pervasive computing, the committee suggests to focus the departments recruitment efforts as follows. The committee's choice of hiring areas reflects the areas of strategic importance that are presently poorly covered by the existing faculty at Stanford (including other non-CS departments at Stanford).

Pervasive computer systems. The pervasive computing vision spans a number of core computer science areas. Perhaps the most important needs arise in the areas of machine learning and software engineering, where the department should seek individuals whose research scales to large and loosely structured data sources. The department has to strengthen its faculty in the areas of privacy and security in large-scale online systems. It should recruit individuals focused on the development of robust software, pliant systems, and safety, security, and privacy of information in large real-world information systems. Within the next ten years, the department should aim to hire about four new faculty in these areas.

Physical and virtual environments: The department should further its existing strength in areas pertaining to computing in physical environments. It shall be acknowledged that the department already possesses significant strength in several key areas of computing in physical and virtual environments. However, given the importance of this societal transformation, we recommend that the department give serious consideration to candidates whose research focus on sensor networks, software engineering, human computer interaction, machine learning, computer vision, and privacy / security. Especially in the area of computer vision the department lacks critical strength; hence it should continue its efforts to recruit a top notch computer vision researcher. In the area of human computer interaction, the department could consider individuals whose research focuses on virtual education or interactive storytelling. Individuals whose research falls within the scope of the University's initiatives (energy, environment, creativity and arts) while retaining a strong CS focus, should be given serious consideration, as should be researchers who have the potential to strengthen the department's links to Stanford's Design Institute (d.school). Within the next ten years, the department should aim to hire six new faculty in these areas.

Computational foundations for other academic disciplines: New faculty hires should strengthen the department's interdisciplinary ties to other departments on campus; while at the same time contribute significantly to core computer science. Obvious inter-departmental areas in which such hires could be made include computational biology, neuroscience, brain imaging, cognitive science, and education. Potential hires arise in the area of data mining of interdisciplinary data sources, such as historical and cultural data, life science data, and personal health data. We recommend that successful hires should have the potential to make strong contributions to a non-CS discipline and to the core of computer science. Within the next years, the department should aim to hire five new faculty in these areas.

Special consideration should be given to individuals who further the SoE Strategic Initiatives on bioengineering, information technology, nanoscience and nanotechnology, and environment and energy.

3.3 Incentives for Existing Faculty

In additional to the faculty hiring plan, the strategic plan committee recommends the creation of a number of incentives and mechanisms for the existing faculty body, to foster innovative and interdisciplinary research and education.

- **Interdisciplinary laboratories and projects.** The department should support the creation of mechanisms for fostering interdisciplinary projects involving multiple faculty members. These can include labs that share equipment and infrastructure (e.g., joint staff), as well as lighter-weight projects that could be formed without the significant institutional overhead and rigidity that is typically associated with new Centers.

- **Curriculum development.** The department should provide teaching credit and seed funds for individuals, who create new interdisciplinary educational opportunities, develop new curricula, and who build infrastructure in the pursuit of new educational venues.

- **Individual support for interdisciplinary research.** The department should earmark fellowships for interdisciplinary students, and encourage situations in which students are co-advised by faculty from different research areas and/or departments. Moreover, support (e.g., in the form of teaching leave) should be provided to faculty moving into a new, interdisciplinary area.

3.4 Corporate Relationships

To adjust to the change in the funding landscape, this committee recommends that the Computer Science Department take active steps in building up new funding opportunities for its faculty. We recommend that the department implements steps to strengthen its corporate project support for individual faculty (or groups of faculty), so that the individual corporate funding level per faculty can be increased. To this end, the Computer Science Forum should consider the recruitment of a technical director of corporate fundraising, who could serve as a technical liaison to sponsoring companies and individual faculty in the department. Such a position could add to the existing staff, whose work focuses largely on the department-wide relationship of member companies.

4. Educational Reform

The strategic plan committee recommends that the department reform its educational offerings and structures. Reforms of the educational programs are urgently needed, most notably for the undergraduate program, but also for its graduate programs.

4.1 Undergraduate Program Reform

The CS Department's undergraduate curriculum has long been viewed as a model for many other departments, due both to its enormous success of the introductory curriculum (the CS10X courses) and to the great wealth of high-quality upper-division courses spanning all sub-areas of Computer Science. Nevertheless, with the growing breadth of the field, it is becoming increasingly harder to convey to students everything that has traditionally been considered the necessary core of the field, while at the same time allowing them to explore new and interdisciplinary directions. This committee feels that the undergraduate curriculum needs to be revised to accommodate a broader set of interests and skills, specifically with an eye towards interdisciplinary education.

The strategic plan committee questions whether, in an age of interdisciplinary education and an ever-increasing breadth of the field of computer, a single curriculum can be maintained for all CS majors. Consequently, the computer science department should slim the core and introduce specialized tracks for the undergraduate student body. In addition to more traditional tracks, such as theory, AI, graphics, or systems, new tracks could also enable students to acquire skills in interdisciplinary areas of study, such as computational biology, human-computer interaction, real-world computing, and others. In recent years, the skills required for computer scientists and engineers have notable shifted towards areas like continuous mathematics, statistics, and human computer interaction. The revised undergraduate program should be designed to acknowledge these shifts; so that our graduates are endowed with a technical skill set that matches the needs of future employers.

The present undergraduate population remains highly unbalanced. Only about 15% of the 'active' undergraduate population is female; 7% is African-American; and 6% is Hispanic, and no single student is Native American (2006 data, Spring Quarter). This imbalance remains unacceptable. The undergraduate program reform should create means to attract more female and minority students into computer science, and take any effort to increase the success rate of these underrepresented groups in the department's educational and research programs.

The department has a strong track record in involving undergraduates in cutting edge research. Building on this track record, this committee proposes that the department identifying new mechanisms that increase both student and faculty involvement in undergraduate research. Student interest is sometimes limited due to lucrative off-campus opportunities over the summer and a lack of research opportunities during the academic year. To grow the undergraduate interest in faculty-led research, the department should create new incentives for undergraduates to get involved such research, especially during the academic year. Faculty involvement in undergraduate research is often limited by the small number of faculty in the department relative to the size of the student body. In growing the faculty, the department needs to place emphasis on the development of

effective mechanisms that leverage the additional faculty time into undergraduate research education.

In the 21st Century, it has become increasingly important that computer science graduates work in teams, often containing people from many other disciplines. At present, our undergraduate education does little to prepare our students to join a multilateral workforce. The department needs to develop mechanisms that improve the communication skills of our undergraduates, especially with other workers whose primary education lies outside the area of engineering. More undergraduate involvement in teaching, for example, through TA-ships or the section leader program, will likely strengthen the undergraduates' ability to become effective technology leaders in society. This committee also suggests incorporating programs and courses focused specifically on team-work and communication skills into the curriculum.

The committee also advises the Stanford CS Department to place more emphasis on hands-on project experience and skills for working in teams. For example, the department may want to strengthen its project courses, capstone classes, and corporate internship opportunities. It may strengthen its ties to the Design Institute (d.school) and create new project courses jointly with faculty in this institute. Similar classes could be added in collaboration with other departments, for example, classes on computational biology that involve both computer scientists and biologists working in teams. Such changes would add critical skills required by the modern multilateral workforce.

It is essential that the department begins implementing such reforms within the next two years. To this end, this strategic plan calls for the creation of an undergraduate curriculum committee, composed of faculty and lecturers in the Computer Science Department and affiliated disciplines. The committee shall be chaired by a faculty-level director of the undergraduate program. Such a position is currently vacant in the department. It is key that this position be filled as soon as possible, so as to not delay the reform of our undergraduate program. The director should also oversee future reforms of the program, and be responsible for monitoring the health of the program and implementing any necessary changes.

4.2 MSCS Program Reform

Similar to the reform of the undergraduate program, the MSCS curriculum has to be updated along similar lines. In particular, it shall be determined whether a smaller core, with a more flexible structure for specialization and interdisciplinary research suit our student body better than the current system. We also recommend strengthening project work, faculty interaction, and communication skills in the MSCS program, analogous to the strategic adjustments necessary in the undergraduate program. The curriculum overhaul should be led by the existing faculty chair of the MSCS program.

In recent years the size of the MSCS program has shrunk slightly and the quality of the student population has improved noticeably. The strategic plan committee recommends a further reduction in the size of this program, to a total of 100 students (including co-terms) for each incoming MSCS

class. It also recommends that the department take active steps to reduce the existing gender and minorities imbalance in its MSCS program.

4.3 PhD Program Adjustment

The Computer Science PhD program requires only minor adjustments. Of specific concern to the strategic plan committee is the department's goal to provide sufficient breadth in the education of its graduates. To ensure a broad knowledge and skills in computer science, this committee recommends that the department explore new mechanisms to strengthen the breadth requirement of our student population. For example, the breadth could be strengthened through adjustments of the qualifying examinations, or the introduction of a light-weight course requirement focused on breadth.

Additionally, the strategic plan committee suggests a review of the PhD requirements and processes. The strategic goals of such a review shall be the strengthening of the PhD candidates, and the awareness in the department of ongoing research in the student body. The department may consider unifying its exam requirements throughout different research areas in CS, and introducing a doctoral thesis proposal requirement to improve the joint awareness of ongoing research and to provide an early feedback mechanism for the student. The committee also recommends modifying the PhD program requirements in ways that strengthens the communication skills of the PhD student body.

5. Authors

The strategic plan was written by Bill Dally, Pat Hanrahan, Scott Klemmer, Daphne Koller, Rajeev Motwani, Mendel Rosenblum, and Sebastian Thrun (committee chair), in consultation with the faculty and affiliates of the Computer Science Department at Stanford University.