COMPUTING RESEARCH NEWS

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Information Technology Worker Shortage Conference

By Fred. W. Weingarten

On January 12 and 13, at the Claremont Hotel in Berkeley, California experts from industry, government, and academia met to discuss the shortage of information technology workers in the United States.

The meeting was co-sponsored by the School of Information Management and Systems at UC Berkeley, the Information Technology Association of America (ITAA), and the Commerce Department, and it turned out to be, in policy and political terms, a pretty big deal. Lots of senior administration officials were there, including Secretary of Commerce Bill Daley, Secretary of Education Richard Riley, Deputy Secretary of Labor Kitty Higgens, and several other officials. Even Vice President Gore participated via a videotaped message. The issue and meeting received front-page coverage in the *New York Times*, the *Washington Post*, several other major newspapers, and was featured in network news broadcasts.

Clearly, both the White House and members of Congress, particularly from high-tech states, are gearing up to run with the issue. But, like anything else in Washington, it will not be without some complicated political battles (even within the computing profession) and possibly some significant implications for computer science and engineering education.

The issue first began to attract political attention early last year with a publicized report from the ITAA, *Help Wanted: The IT Workforce Gap at the Dawn of a New Century*. The report, based on a telephone survey of job vacancies at mid- and large-size employers, asserted a current gap of 190,000 unfilled jobs with projections of more than one million new jobs created in the industry by the year 2004 (see "IT Companies Heavily Courting CS Grads," *CRN*, May 1997).

Although the ITAA report received some criticism of its methodology and use of data, the testimonials of senior industry executives together with corrobora-

tive data on job growth from the Bureau of Labor Statistics lent credence to the overall message. In some ways, looking at the extraordinarily rapid growth in the technology, the surprise would be if there were no shortage!

But, even accepting that premise leaves a lot of unanswered questions (and, as will be seen below, not all agree with it). The Commerce Department's Office of Technology Policy (OTP) decided to take a closer look and issued its own report last fall. OTP's conclusion is apparent in the report's title, *America's New Deficit: The Shortage of Information Technology Workers*.

OTP narrowed the definition of IT workers (somewhat ambiguous in the ITAA report) to four "core" information technology professions: computer scientists, computer engineers, systems analysts, and computer programmers. Clearly, some might object to that narrowing, given the growing role of content and information specialists in the creation of systems.

The advantage is that the definition fits current labor projection definitions and models, but these days, a development team creating a new education CD-ROM, for example, might consist of only one or two programmers teamed with content experts, graphic designers,

media specialists, and learning specialists. All would be needed to produce an effective and marketable product, all might need to have more than passing knowledge of information technology, not all would qualify as "core" IT workers. But, the policy analyst's sensible approach is usually to start where you have data and go from there.

OTP also concluded that we were facing a shortage, interestingly, not only based on the continued growth of information technology as an economic sector, but on the growth in what they referred to as "information intensity" across the economy – that is, the proportion of information workers employed in other "user" sectors (a proportion that is particularly growing is the service sector.) This tells us not only where the demand is coming from, but gives some clues about the skills new workers will need. It also says that the problem is not just one for the information industry, but that the pain of any severe IT worker shortage would be felt throughout the economic structure.

The OTP report set the stage for the January conference. The conference, seemingly intended to attract and display high-level interest in the shortage issue, consisted of four

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KDI Initiative Offers $48 Million in Grants

By Louise Arnheim

Within days of receiving the final go-ahead from the House, the National Science Foundation (NSF) released a $48 million proposal solicitation for its Knowledge and Distributed Intelligence (KDI) initiative. KDI is an NSF-wide effort to capitalize upon recent achievements in computing power and connectivity.

Over the next few months, the Foundation will be seeking research proposals in three multidisciplinary program areas: Learning and Intelligent Systems (LIS), Knowledge Networking (KN), and New Computational Challenges (NCC). Individuals and groups from US colleges, universities, and nonprofit research institutions may apply for the grants (and NSF notes that industry partnerships are "encouraged"). Proposals are due May 8, with letters of intent expected by April 1.

Mike McCloskey, Program Manager, Human Cognition and Perception, is Chair of NSF's internal working group on KDI, which meets weekly and is comprised of program officers from the six NSF directorates: Biological Sciences

(BIO); Computer and Information Science and Engineering (CISE); Education and Human Resources (EHR); Engineering (ENG); Mathematical and Physical Sciences (MPS); and Social, Behavioral, and Economic Sciences (SBE). The group will manage the competition, solicitation, and review of submitted grants. It will also develop a plan for KDI's future.

McCloskey, in a recent talk with *CRN* regarding the proposal solicitation, stated, "We're now at a point where there have been huge advances in computer power and computer connectivity," he said. "The aim of KDI is to do everything we can to maximize the extent to which we can exploit these developments."

In several ways, KDI affirms the adage that "everything old is new again." First, KDI is the latest in a series of Foundation activities such as the new supercomputing partnerships (Partnerships for Advanced Computational Infrastructure), or PACI (see *CRN*, May 1997) and the Digital Libraries Initiative. Over $355 million has already been allocated for these ongoing projects.

Second, New Computational Challenges (NCC) is a continuation

of NSF projects such as the Grand Challenge.

Third, another existing program, Collaborative Research on Learning Technologies (CRLT), was recently made a part of LIS. In fact, a first solicitation for LIS was issued in late 1996 (the announcement followed a series of NSF-sponsored workshops held between the fall of 1995 and spring of 1996). Then, in October 1997, NSF announced $22.5 million in grants for these 28 projects.

Also under the KDI umbrella is the Foundation's part in the Next Generation Internet (NGI) initiative [NSF is one of several federal agencies such as the Defense Advanced Research Projects Agency (DARPA) and the National Aeronautics and Space Administration (NASA) that are involved in NGI-related research (see *CRN*, November 1998; also September 1997)]. Congress set aside a separate $10 million under KDI for the Foundation's efforts at "enhancing Internet capabilities," but no grants will be awarded in this area.

Though NSF officials testified before Congress last year on KDI and funding was approved for FY '98,

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Expanding the Pipeline

Supporting Students with Disabilities

By Joan Francioni

Given that you do not have a physical disability now, do you think you could still do computer science if you were to become blind or be unable to use your hands to type or need to use a wheelchair? Your mind would continue to function in the same logical way. With the help of computer adaptive technology, such as a screen reader, head-controlled keyboard input or just a higher computer table, you would still be able to work on the computer. Thus, there is really no reason why you could not still do computer science. Yet, we have very few students in the computer science pipeline with physical disabilities. Is there some innate reason why these students cannot *learn* to be computer scientists? Surprisingly, some people in the sciences believe this is true. In this article, we will identify some of the barriers students with disabilities face in science, engineering and mathematics, and look at what is being done and what can be done to remove these barriers.

First, some general statistics. According to the US Census Bureau, in 1995 there were approximately 25 million people in the US between the ages of 15 and 22, of which approximately 3 million (12%) had some type of disability. The Americans with Disabilities Act of 1990 defines disability as a "physical or mental impairment that substantially limits one or more of the major life activities." This covers a broad range of disabilities. Thus, as is true of the general population, not all people with disabilities will have the aptitude to become computer scientists. However, as you look around at your students, it is very evident that there are far fewer computer science majors with disabilities than 12% of the group.

In the past, a significant barrier to success as a computer scientist was the inability of the person with the disability to interact with a computer independently. As little as seven years ago, people with visual impairments needed another person to sit and read out loud to them what was being displayed on the screen. People who could not type with their hands had to resort to very slow and contorted ways of input, such as using a pencil held in the mouth to type. Although special-purpose adaptive computer devices existed at that time, general purpose computing was still very much inaccessible. It was not until the early 1990's that reliable and affordable software/hardware adaptive technology started becoming readily available in the PC world. Today basic computer adaptive technology includes screen readers for ASCII, as well as "Windows" output, word completion/prediction software, alternative input devices, affordable scanners and intelligent screen magnifiers.

Adaptive technology that works in a UNIX environment has been slower in coming than for PCs; however, that too is now changing.

Limited access to a computer is not the only barrier for a potential computer science student with a disability. These students must also take, and pass, courses in a variety of subjects. In particular, they must take CS, science and mathematics classes (and possibly engineering classes). Adaptive computers help students a great deal in their general education classes. With a scanner and screen reader or text-to-Braille conversion program, blind students have access to all the same printed material as the other students. In addition, they can easily generate written homework and reports for sighted instructors. Students with communication disabilities or hearing disabilities can converse on an equal par with teachers and classmates using e-mail. When Web pages are designed correctly, visually impaired students have just as much information available to them as sighted students.

That's the good news. Unfortunately, students with disabilities face additional barriers in their science and mathematics classes. In the physical sciences, lab experiments pose a wide range of structural problems for students with disabilities, ranging from lab tables that are too high to instruments that are difficult to manipulate. Understanding graphs, charts and scientific notation is necessary in science and mathematics courses and can be difficult for students with visual disabilities. Learning to program using a graphical environment poses unique problems. Computer adaptive technology, however, can help break these barriers down as well. For example, devices that communicate information from sensors over serial ports to PCs, such as IBM's Personal Science Laboratory and Radio Shack's Micronta digital multimeter, allow students to use a computer to "read" instruments measuring such things as temperature, pH, distance and voltage. Portable Braille note-takers or laptops allow students to take their own notes during both labs and lectures.

As for help for the visually impaired in understanding graphs, charts, and scientific notations, adaptive technology offers some viable alternatives. The AsTeR system (Audio System for Technical Readings) produces an audio version of LaTex documents that reflects the structure and content of mathematical formulas. VersaPoint Graphics is a software "capture" package that converts graphical PaintBrush-type images into embossable ASCII format images that can be drawn by a raised-line printer. Other tools of this type also exist or are currently being developed for standard documentation formats, such as

Word and HTML.

The basic key, of course, to being able to develop tools like AsTeR and VersaPoint is having information stored digitally. This facilitates rendering the information in different ways, using different media. A problem occurs, however, when there is not a clear separation between the data information and the presentation information in the digital form of a document. For example, when an HTML file contains embedded format commands, the presentation information is tied in with the data information. A tool that is displaying the document in high-contrast colors will fail on a <font color=#993333> in-line format command. On the other hand, if these components are separated, as is the case if the HTML document is designed to use a style sheet, then a visually impaired user can use a magnification or aural style sheet to present the information in an accessible way. This is the goal of "cascading style sheets," which are currently under development. [See suggestion Number 1 below.]

All of these techniques and tools point to more inclusion of students with disabilities in the computer science pipeline. The sad part of the story, however, is that individuals with disabilities report that the single most significant barrier they face is negative attitudes on the part of faculty and employees. Sometimes these negative attitudes are of the subtle variety – little encouragement for disabled students to pursue certain fields, unawareness of how to accommodate students with special needs, no serious effort to recruit students with disabilities. In more blatant situations, administrators and faculty just do not believe that students with disabilities can perform well in science, engineering and mathematics. This is not true, and there are case studies to the contrary in the few schools that actively work to recruit disabled students into science, engineering and mathematics programs. The important thing to remember is that learning these subjects is a cognitive process, involving systematic thought processes. It may be helpful, but it is not necessary to be able to see, touch or hear to understand science and mathematics.

Obviously, school is going to be more difficult for a student with a disability than for one without. Fortunately, adaptive computer technology can significantly increase the chance of success for these students. The use of such specialized computer devices not only allows students with disabilities to do their work, it also gives them the freedom and integrity to work independently. It would seem particularly ironic, therefore, if computer science as a major was inaccessible to these students. We should all work to

Affiliate News

Numerical Computation in the Information Age

By John Guckenheimer
President, SIAM

The continuing explosion of the computer industry raises new challenging problems daily. At the same time, many old challenging problems remain important but unsolved. It is all too easy to pretend that this is not so, in our haste to go on to larger computational tasks. We assume that because a problem is familiar that it is no longer a problem. I hear this attitude today in discussions of many numerical questions. We are conducting ever more complex computations built upon the assumption that underlying numerical methods are mature and reliable. Often, these assumptions are not valid.

Many computer scientists have shifted their attention to new uses of computers whose explosive growth has caught us by surprise during the past few years. Information technologies are seen as a broader arena in which computer science is central. I have a poor understanding of the forces that have led to the current state of affairs, but it seems evident that critical research areas for computing are being neglected or de-emphasized. I discuss this issue in terms of simulation and modeling, relying upon both my research expertise and my perspective as president of SIAM. SIAM is an organization whose mission lies at the heart of computational science.

Few academic departments regard the numerical aspects of computing as part of their core activities. Oversimplifying attitudes, many mathematicians see computation as inferior to proving theorems, many computer scientists focus their attention on linguistic issues or information technologies, and computational scientists from other disciplines believe that Moore's law will solve their remaining problems. We seem to overlook the continuing contributions that mathematics makes to improvements in computing. When we bundle existing algorithms into libraries and wrap them into packages to facilitate easy use, we create *de facto* standards that make it easy to ignore numerical analysis. We regard the existing base as static and invest in the development of problem-solving environments and high-level languages. This is needed, but we also need to maintain our investment in continuing research on algorithms themselves.

I maintain that the relative neglect of mathematical aspects of computation weakens the foundations of our growing computational enterprise, foundations that desperately need to be strengthened to support computation at the interface between computers and the physical world. Computers are far more than passive devices for information storage and retrieval. Digital technologies make computers integral components of endeavors such as fly-by-wire flight control, programmed stock trading, and art-to-part manufacturing. Our success in these endeavors is dependent upon efficient and accurate computations.

Algorithmic problems arise repeatedly as we attempt new applications. There are frequently common features in these computational problems, and research directed at finding general solutions to classes of questions has been a critical part of the increased use of digital technologies.

To make this point more concretely, I shall describe some of the current issues that are related to simulation, an area in which I have a personal interest. We seek to implement ambitious simulations of global climate change, entire automobiles, electric power networks, military battles, stock markets, and the human brain. Moreover, we want high fidelity in those simulations so that they can be used in planning public policy, industrial design, enhancing reliability of infrastructure systems, personnel training, improving investment earnings, and the verification of

> CRA is pleased to welcome its newest industrial member:
>
> *Sony US Research*

ACM Policy '98 Conference

Shaping Policy in the Information Age

May 10-12, Washington DC is the time and place for the computing community to focus on public policy issues affecting future applications of computing. Attendees will interact with leaders from academia, industry, Congress, and executive agencies, and participate in debates on policy issues including Universal Access, Electronic Commerce, Intellectual Property, and Education Online.

Program participants include Jim Barksdale of Netscape, Juris Hartmanis (NSF), John Gage (founder of Netday and formerly of Sun), Gordon Bell (Microsoft), Senators Olympia Snowe and John McCain, Congresswomen Connie Morella and Anna Eshoo, Congressmen Vern Ehlers and Rick Boucher, Pam Samuelson (Berkeley), Esther Dyson (EFF), Ira Magaziner (White House staff), and Ray Smith (president of Bell Atlantic).

CRA, in its role as the primary representative of the computer science community on policy issues affecting computer science research and engineering, is one of seven organizations cooperating with ACM in planning the conference.

Chaired by Ben Shneiderman (University of Maryland) and C. Dianne Martin (George Washington University), the focus of the conference on Sunday May 10 is ethical and social impacts, with the ACM Awards Banquet in the evening; on May 11 and 12, the theme is policy issues.

For conference and registration information see http://www.acm.org/usacm/events/policy98/

The USENIX Association

Looking for Places to Publish or Funding for Your Student
By Cynthia Deno

The USENIX Association is proud to be a member of the Computing Research Association. In joining, we recognized a set of shared values and goals: the strengthening of computing research and of the community engaged in computing research, and the support and promotion of education in the computing fields.

The USENIX Association and its members are dedicated to problem-solving with a practical bias and fostering innovation and research that works. This commitment to innovation and research manifests itself in, among other things: 1) sponsoring venues for communication and exploration of the results of new research and innovation; 2) providing for the publication of new work; 3) supporting the university and college computer science communities from which much new research comes; and 4) fostering professional development and opportunities for participation by students.

USENIX is the Advanced Computing Systems Association. Its members are the computer technologists responsible for many of the innovations in computing we enjoy today. USENIX was founded in 1975 by the creators and earliest adopters of UNIX. While we remain the association for UNIX gurus, our members aspire to technical excellence in software and systems within today's reality of rapidly changing technologies amid vast networks linking a wide variety of computer platforms.

CONFERENCES
While each conference is different, all USENIX conferences offer refereed papers featuring previously unpublished technical information and work-in-progress reports. The USENIX tutorial program is well known for delivering top quality intensive instruction in new and essential, new technologies, which are often presented by the people who led in their development, e.g., Kirk McKusick on BSD internals, John Osterhout on Tcl and Tk, Tom Christensen on Perl, and Eric Allman on Sendmail.

Presentations are greeted with spirited discussion in an atmosphere of critical thought, freewheeling exchange of ideas and airing of technical issues unfettered by commercialism. USENIX annually sponsors a broad-topic technical conference, a systems administration (LISA) conference, and a variety of smaller conferences, symposia and workshops on such topics as operating systems design and implementation, object-oriented technologies, electronic commerce, domain-specific languages, and systems security. Top echelon researchers and computer scientists in software and systems attend to debate state-of-the-art technical developments. Highly informal, USENIX conferences are fun, thought-provoking and, above all, practical.

USENIX conferences offer researchers the opportunity for timely publication of their results in a highly respected venue. Proceed-

1996-1997 CRA Taulbee Survey

Undergrad Enrollments Keep Booming, Grad Enrollments Holding Their Own

By Dexter Kozen and Stu Zweben, Co-chairs, CRA Taulbee Survey

This article and the accompanying tables present the results of the 27th annual CRA Taulbee Survey[1] of Ph.D. granting departments of computer science (CS) and computer engineering (CE) in the United States and Canada. This survey is conducted annually by CRA for the purpose of documenting trends in student enrollment, employment, and faculty salaries. Information is gathered during the fall and early winter. Responses received by January 22 are included in the tables.

Information on degree production and enrollment applies to the previous academic year (1996-1997). Information on faculty salaries applies to the current academic year (1997-1998). Faculty salaries are those effective January 1, 1998. Readers should keep in mind that survey results are from Ph.D. granting departments only.

This article reviews the most significant results of the survey, with particular attention to those that differ markedly from last year or that appear to indicate long-term trends.

This year we received responses[2] from 129 (bachelors) 133 (masters and Ph.D) departments regarding production; 129 (bachelors), 133 (masters), and 135 (Ph.D.) departments regarding enrollment; 135 departments regarding faculty growth; and 130 departments regarding salary data (this includes US CS, US CE, and Canadian) for a response rate of over 80%. We thank all respondents for their timely completion of the questionnaire

Degree Production (Tables 1–6)

There were a total of 894 Ph.D. degrees awarded in 1997 by the 131 responding departments. This is down from 915 last year and continues a slight but steady downward trend from the peak of 1,113 in 1992. The prediction from last year's survey that 1,110 Ph.D's would be awarded in 1997 was again overly optimistic, but this year the discrepancy was even greater than normal. The forecast for next year is a continued decline, perhaps as much as 8%. However, new enrollment in Ph.D. programs is up significantly for the second straight year (see the section on enrollments, Table 9) and there was a 14% increase over last year in the number of students passing the qualifying exam, so a long-term upswing in Ph.D. production is likely if programs can retain their newly enrolled students.

Table 4 gives the areas of specialization and types of first appointments for last year's Ph.D. recipients. The expanded format introduced last year was kept, with 10 areas of specialization instead of the previous 6 and further breakdown according to the type of position in Ph.D. granting departments. There was significant improvement in the percentage of unknown areas of specialization, dropping to 19.0% from 21.3% last year.

The number of bachelor's degrees awarded in 1997 by 131 responding departments was 8,063, off 4.1% from the 8,411 produced by 128 departments in 1996, but still significantly higher than the 7,561 awarded in 1995. The number of master's degrees, which was essentially flat between 1995 and 1996 with 130 departments reporting, rose about 4.3% in 1997 with 131 departments reporting.

The gender and ethnicity statistics for bachelor's and master's degree recipients remained fairly static with the exception of master's degrees awarded to Native Americans or Alaskan natives, which dropped precipitously from 45 to 4. However, the percentage of master's degrees awarded to women (among degree recipients of known gender) rose from 20.4% in 1996 to 22.7% in 1997. For Ph.D. recipients, the combined gender and ethnicity statistics were not reported this year because of the difficulty in collecting the data, but gender and ethnicity were reported separately (Tables 2 and 3). There was an alarming drop in the number of Ph.D. degrees awarded to Native Americans (from 5 in 1996 to 0 in 1997), African Americans (from 11 in 1996 to 6 in 1997), and Hispanics (from 27 in 1996 to 8 in 1997). The percentage of Ph.D. degrees awarded to women showed a modest rise from 12% in 1996 to 14% in 1997.

Student Enrollment (Tables 9–11)

The big news is the continued explosion in undergraduate enrollments for the second straight year (Table 9). Still reeling from last year's 40% increase over the previous year, academic departments were hit with another 39% jump in 1997.

This will undoubtedly translate to a significant rise in the number of bachelor's degrees awarded starting next year. Meanwhile, many departments are finding their resources stretched to the limit as they struggle to cope with overflowing classrooms. At Cornell, more than a quarter of those freshmen engineers expressing a preference listed computer science as their major of choice (more than any other engineering major) and by 1999, the number of graduating computer science majors will have more than doubled since 1995. At Ohio State, the number of premajors (those who haven't yet completed all the requirements to formally be admitted to a major) in computer science jumped 35% over last year. As a percentage of undergraduate engineering students, computer scientists have risen to 19.5%, up from 15.8% last year and 10.9% the year before.

Enrollments also increased at the graduate level, but somewhat less dramatically. From 1995 to 1996, new enrollment in Ph.D. programs rose sharply by about 26%. In 1997 the trend continued with 1,440 Ph.D. students enrolled, a rise of 7% over 1996, with 131 departments reporting in 1997 versus 130 in 1996. Master's degree enrollments remained relatively static.

The percentage of women enrolled in Ph.D. programs increased slightly from 16.2% in 1996 to 17.0% in 1997. But the major demographic change is in ethnicity of students in the Ph.D. programs.

Table 1. Ph.D. Production by Ranking

	Ph.D.s Produced	Average per Dept.	Ph.D.s Next Year	Average per Dept.	Passed Qualifier	Average per Dept.
US CS Ranked 1-12	207	17.3	237	19.8	186	15.5
US CS Ranked 13-24	111	11.1	117	11.7	124	12.4
US CS Ranked 25-36	102	9.3	110	10.0	92	8.4
US CS Other	343*	4.4	426+	5.5	484	6.2
Canadian CS	89@	12.7	93~	13.3	81	11.6
US CE	41#	6.8	54&	9.0	35	5.8
Total	**893****	**7.2**	**1,037**	**8.4**	**1,002**	**8.1**

Table 2. Gender of Ph.D. Recipients

	CS		CE		CS & CE	
Male	699	(85%)	64	(90%)	763	(85%)
Female	122	(15%)	7	(10%)	129	(14%)
Total	**823****		**71**		**894**	

Table 3. Ethnicity of Ph.D. Recipients

	CS		CE		CS & CE	
Nonresident Alien	298	(36%)	27	(38%)	325	(36%)
African American, Non-Hispanic	5	(1%)	1	(1%)	6	(1%)
Native American or Alaskan Native	0	(0%)	0	(0%)	0	(0%)
Asian or Pacific Islander	99	(12%)	8	(11%)	107	(12%)
Hispanic	7	(1%)	1	(1%)	8	(1%)
White, Non-Hispanic	365	(44%)	23	(32%)	388	(43%)
Other/Not Listed	22	(3%)	11	(0%)	33	(4%)
Subtotal	**796**	**(97%)**	**71**	**(100%)**	**867**	**(97%)**
Ethnicity Unknown	27	(3%)	0	(0%)	27	(3%)
Total	**823**	**(100%)**	**71**	**(100%)**	**894**	**(100%)**

Table 1

* Includes 29 CE degrees granted by these CS departments
@ Includes 6 CE degrees granted by these Canadian departments
\# Includes 10 CS degrees granted by these CE departments
\+ Includes 39 CE degrees granted by these CS departments
~ Includes 10 CE degrees granted by these Canadian departments
& Includes 14 CS degrees granted by these CE departments

Footnotes

[1] The title of the survey honors the late Orrin E. Taulbee of the University of Pittsburgh, who conducted these surveys for the Computer Science Board from 1970 until 1984.

[2] In some instances, departments only answered selective questions within a table or a section. Therefore, for individual fields within tables the response rate may vary ± 3.

**Totals do not match: The reader may find that totals from certain tables do not equal each other, even though theoretically they should. These discrepancies stem from inconsistencies in the way departments answered different questions. We tried to minimize this by calling departments that provided inconsistent answers.

1996-1997 CRA Taulbee Survey

Table 4. Employment of New Ph.D. Recipients by Specialty

New Ph.D's in Ph.D.-Granting Depts.	Artificial Intelligence/ Robotics	Hardware/Architecture	Numerical Analysis/ Scientific Computing	Programming Languages/ Compilers	OS/Networks	Software Engineering	Theory/Algorithms	Graphics/ Human Interfaces	Databases/ Information Systems	Other/Unknown	Total
Tenure-Track	23	6	1	16	20	6	17	11	9	2	111
Researchers	11	1	5	4	3	4	5	6	6	4	49
Postdocs	18	5	7	6	1	2	11	1	1	3	55
Instructors	7	1	0	1	2	1	0	1	0	9	22
New Ph.D's, Other Categories											
Other CS/CE Dept.	8	0	2	4	2	0	7	1	5	1	28
Non-CS/CE Dept.	2	1	0	1	0	3	0	3	3	1	14
Industry	57	42	19	37	81	33	37	25	41	50	422
Government	3	2	0	3	4	3	1	3	1	7	27
Self-Employed	6	0	0	0	1	1	2	1	0	4	15
Employed Abroad	7	3	2	2	2	4	5	2	7	9	43
Unemployed	0	1	1	3	0	0	1	1	1	0	8
Other/Unknown	5	0	3	2	1	3	3	1	2	80	100
Total	**145**	**62**	**40**	**79**	**117**	**60**	**89**	**56**	**76**	**170**	**894**

Table 5. Gender of Bachelor's and Master's Recipients

	Bachelor's			Master's		
	CS	CE	Total	CS	CE	Total
Male	5,284 (75%)	786 (74%)	6,070 (75%)	2,870 (76%)	498 (74%)	3,368 (76%)
Female	1,141 (16%)	124 (12%)	1,265 (16%)	819 (22%)	172 (16%)	991 (22%)
Unknown	577	151	728	84	-	84
Total	**7,002**	**1,061**	**8,063**	**3,773**	**670**	**4,443**

Table 6. Ethnicity of Bachelor's and Master's Recipients

	Bachelor's			Master's		
	CS	CE	Total	CS	CE	Total
Nonresident Alien	400	71	471 (6%)	1,585	313	1,898 (43%)
African American, Non-Hispanic	123	34	157 (2%)	44	4	48 (1%)
Native American or Alaskan Native	9	4	13 (-%)	4	0	4 (-%)
Asian or Pacific Islander	936	159	1,095 (14%)	442	76	518 (12%)
Hispanic	146	34	180 (2%)	56	10	66 (2%)
White, Non-Hispanic	3,145	586	373 (46%)	1,186	147	1,333 (31%)
Other/Not Listed	56	5	61 (1%)	96	10	106 (2%)
Subtotal	**4,815**	**893**	**5,708 (71%)**	**3,413**	**560**	**3,973 (89%)**
Ethnicity Unknown	2187	168	2,355 (29%)	360	110	470 (11%)
Total	**7,002**	**1,061**	**8,063 (100%)**	**3,773**	**670**	**4,443 (100%)**

Table 7. Bachelor's Degree Candidates for 1997-98

	CS	CE	CS & CE
US CS Ranked 1-12	1,335 (17%)	48 (4%)	1,383 (15%)
US CS Ranked 13-24	754 (9%)	194 (17%)	948 (10%)
US CS Ranked 25-36	482 (6%)	36 (3%)	518 (6%)
US CS Other	3,882 (47%)	691 (61%)	4,573 (49%)
Canadian CS	1,622 (20%)	50 (4%)	1,672 (18%)
US CE	40 (1%)	124 (11%)	164 (2%)
Total	**8,115 (100%)**	**1,143 (100%)**	**9,258 (100%)**

Table 8. Master's Degree Candidates for 1997-98

	CS	CE	CS & CE
US CS Ranked 1-12	554 (14%)	65 (10%)	619 (13%)
US CS Ranked 13-24	446 (11%)	3 (1%)	449 (10%)
US CS Ranked 25-36	348 (9%)	0 (0%)	348 (8%)
US CS Other	2,249 (57%)	166 (26%)	2,415 (52%)
Canadian CS	285 (7%)	50 (7%)	335 (7%)
US CE	83 (2%)	365 (56%)	448 (10%)
Total	**3,965 (100%)**	**488 (100%)**	**4,614 (100%)**

Table 9. New Students in Fall 1997

	Bachelor's Full Time			Dept Average	Master's Full Time			Dept Average	Ph.D. Full Time			Dept Average
	CS	CE	Total		CS	CE	Total		New Admit	MS to Ph.D	Total	
US CS Ranked 1-12	2,244	63	2307	192.3	345	48	393	32.8	267	14	281	23.4
US CS Ranked 13-24	1,379	469	1848	184.8	437	5	442	40.2	189	22	211	21.1
US CS Ranked 25-36	841	0	841	84.1	194	0	194	17.6	188	7	195	17.7
US CS Other	9,233	1,450	10,683	138.7	1,697	128	1,825	23.1	558	85	643	8.2
Canadian CS	3,462	144	3,606	240.4	299	26	325	21.7	68	18	86	3.7
US CE	102	416	518	74	56	175	231	33	22	2	24	3.4
Total	**17,261**	**2,542**	**19,803**		**3,028**	**382**	**3,410**		**1,292**	**148**	**1,440**	

1996-1997 CRA Taulbee Survey

Table 10. Gender of Enrolled Ph.D. Students

	CS	CE	CS & CE
Male	5,086	406	5,492
Female	1,079	77	1,156
Unknown	141	0	141
Total	**6,306**	**483**	**6,789**

Table 11. Ethnicity of Enrolled Ph.D. Students

	CS	CE	CS & CE
Nonresident Alien	2,610	324	2,934
African American, Non-Hispanic	120	8	128
Native American or Alaskan Native	5	3	8
Asian or Pacific Islander	520	19	539
Hispanic	102	9	111
White, Non-Hispanic	2,482	111	2,493
Other/Not Listed	155	3	158
Subtotal	**5,994**	**477**	**6,471**
Ethnicity Unknown	312	6	318
Total	**6,306**	**483**	**6,789**

Table 12. Prior Education of New Ph.D. Students

Bachelor's in CS or CE			% of Total
US CS Ranked 1-12	191 of	281	(68%)
US CS Ranked 13-24	111 of	211	(53%)
US CS Ranked 25-36	157 of	195	(81%)
US CS Other	377 of	643	(59%)
Canadian CS	70 of	86	(81%)
US CE	11 of	24	(46%)
Total	**917 of**	**1,440**	**(64%)**

The percentage of nonresident aliens jumped from 35.6% in 1996 to 45.3% in 1997. In contrast, the percentage of Asian and Pacific Islanders dropped sharply. This may be partially attributable to a change in the survey form, which more clearly distinguished residents from nonresidents. It may be that in previous years many nonresident aliens were classified as Asian or Pacific Islanders. Adding the two groups together accounted for 49.5% of the total in 1996 and 53.7% in 1997.

Faculty Demographics

In 1996, 77.7% of tenure-track faculty were associate or full professors, while in 1997 the percentage rose to 80.1%.

Faculty Salaries

Average salaries at US institutions rose 2.5-4.3%, with the smallest increase at the full professor level and the largest at the assistant professor level (Table 27). Canadian salaries fared worse, posting only a 1-3.5% increase. Salaries for US institutions are 9-month salaries and are reported in US dollars; those for Canadian institutions are 12-month salaries and are reported in Canadian dollars.

The overall mean salaries reported in the center column in Tables 20-28 are unweighted means, calculated by averaging the mean salaries as reported by each school. They are not weighted by the number of faculty.

Rankings

For tables that group computer science departments by rank, the rankings are based on information collected in the 1995 assessment of research and doctorate programs in the United States by the National Research Council.

The top 12 schools in this ranking are Stanford University, Massachusetts Institute of Technology, University of California at Berkeley, Carnegie Mellon University, Cornell University, Princeton University, University of Texas at Austin, University of Illinois at Urbana-Champaign, University of Washington, University of Wisconsin at Madison, Harvard University, and California Institute of Technology.

The departments ranked 13-24 are Brown University, Yale University, University of California at Los Angeles, University of Maryland at

Faculty Growth in Fiscal Year 1997 - 1998

Table 13. Anticipated Faculty Growth by Position

	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	Five-Year Increase	
Tenure-Track	2,503	2,505	2,469	2,576	2,636	2,672	169	(7%)
Researcher	303	327	358	374	390	406	103	(34%)
Postdoc	209	232	253	270	283	297	88	(42%)
Instructor	317	317	321	318	321	324	7	(2%)
Other/Not Listed	159	142	213	146	148	150	-9	(-6%)
Total	**3,491**	**3,523**	**3,614**	**3,684**	**3,778**	**3,849**	**358**	**(10%)**

Table 14. Anticipated Faculty Growth by Ranking

	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	Five-Year Increase	
US CS Ranked 1-12	526	489	515	534	547	553	27	(5%)
US CS Ranked 13-24	407	440	464	437	447	458	51	(13%)
US CS Ranked 25-36	305	301	322	334	319	324	19	(6%)
US CS Other	1,640	1,661	1,691	1,731	1,799	1,836	196	(12%)
Canadian CS	485	495	478	498	509	518	33	(7%)
US CE	128	137	144	150	157	160	32	(25%)
Total	**3,491**	**3,523**	**3,614**	**3,684**	**3,778**	**3,849**	**358**	**(10%)**

Table 15. Gender of Newly Hired Faculty

	Tenure-Track		Researcher		Postdoc		Other	
Male	117	(83%)	47	(85%)	66	(92%)	69	(78%)
Female	24	(17%)	8	(15%)	6	(8%)	19	(22%)
Total	**141**		**55**		**72**		**88**	

Table 16. Ethnicity of Newly Hired Faculty

	Tenure-Track		Researcher		Postdoc		Other	
Nonresident Alien	16	(11%)	7	(13%)	17	(24%)	0	(0%)
African American, Non-Hispanic	2	(1%)	2	(4%)	0	(0%)	1	(1%)
Native American or Alaskan Native	0	(0%)	0	(0%)	0	(0%)	0	(0%)
Asian or Pacific Islander	31	(22%)	12	(22%)	14	(19%)	16	(18%)
Hispanic	2	(1%)	0	(0%)	2	(3%)	0	(0%)
White, Non-Hispanic	84	(60%)	32	(58%)	35	(49%)	65	(74%)
Other/Not Listed	2	(1%)	0	(0%)	0	(0%)	3	(3%)
Subtotal	**137**	**(96%)**	**53**	**(97%)**	**68**	**(95%)**	**85**	**(96%)**
Did Not Indicate	4	(3%)	2	(4%)	4	(6%)	3	(3%)
Total	**141**		**55**		**72**		**88**	

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College Park, New York University, University of Massachusetts at Amherst, Rice University, University of Southern California, University of Michigan, University of California at San Diego, Columbia University, and University of Pennsylvania[3]

The departments ranked 25-36 are University of Chicago, Purdue University, Rutgers–State University of New Jersey, Duke University, University of North Carolina at Chapel Hill, University of Rochester, State University of New York at Stony Brook, Georgia Institute of Technology, University of Arizona, University of California at Irvine, University of Virginia, and Indiana University.

Acknowledgments

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[3] Although the University of Pennsylvania and the University of Chicago were tied in the National Research Council rankings, CRA made the arbitrary decision to place Pennsylvania in the second tier of schools.

All ethnicity tables: "Asian" includes people originating from the Pacific Islands, China, Japan, Korea, the Philippine Islands, Samoa, India and Vietnam; "white" includes people originating from Europe, North Africa and the Middle East.

All tables with rankings: Statistics sometimes are given according to departmental rank. Schools are ranked only if they offer a CS degree and according to the quality of its CS program as determined by reputation. Those that only offer CE degrees are not ranked, and statistics are given on a separate line, apart from the rankings. In Table 1, the "Ph.D.s Produced" column shows the number of CS and CE degrees produced throughout the rankings. While CE degrees are mixed into all rank categories, there are no CS degrees in the CE category.

All faculty tables: The survey makes no distinction between faculty specializing in CS versus CE programs. We tried to minimize inclusion of any faculty in electrical engineering.

Table 17. Gender of Professors

	Assistant	Associate	Full
Male	411 (80%)	848 (90%)	1044 (94%)
Female	101 (20%)	100 (10%)	62 (6%)
Unknown	2 -	0	0
Total	**514**	**948**	**1,106**

Table 18. Ethnicity of Professors

	Assistant	Associate	Full
Nonresident Alien	36 (7%)	6 (1%)	6 (1%)
African American, Non-Hispanic	5 (1%)	5 (1%)	2 (-%)
Native American or Alaskan Native	1 (-%)	0 (0%)	1 (-%)
Asian or Pacific Islander	102 (20%)	230 (24%)	140 (13%)
Hispanic	15 (3%)	6 (1%)	13 (1%)
White, Non-Hispanic	328 (64%)	651 (67%)	863 (78%)
Other/Not Listed	15 (3%)	18 (2%)	32 (3%)
Subtotal	**502 (98%)**	**934 (96%)**	**942 (96%)**
Ethnicity Unknown	12 (2%)	32 (3%)	49 (4%)
Total	**514 (100%)**	**966 (99%)**	**1,106 (100%)**

Table 19. Faculty Losses

	Total
Died	5
Retired	37
Took Academic Position Elsewhere	62
Took Nonacademic Position	53
Remained, Changed to Part Time	9
Other	9
Unknown	2
Total	**177**

Faculty Salaries in Fiscal Year 1997 - 1998

Table 20. Nine-Month Salaries, 111 Responses of 133 US CS Departments

Faculty Rank	# Faculty	Reported Salary Minimums			Average of all salaries	Reported Salary Maximum		
		Minimum	Mean	Maximum		Minimum	Mean	Maximum
Assistant	434	$29,000	$54,880	$68,000	$58,297	$49,822	$60,752	$80,000
Associate	757	$33,000	$59,972	$82,500	$66,544	$52,436	$73,904	$97,200
Full	906	$41,000	$72,028	$110,367	$89,821	$60,850	$113,488	$212,500

Table 21. Nine-Month Salaries, 11 Responses of 12 US CS Departments Ranked 1-12

Faculty Rank	# Faculty	Reported Salary Minimums			Average of all Salaries	Reported Salary Maximum		
		Minimum	Mean	Maximum		Minimum	Mean	Maximum
Assistant	63	$56,921	$59,488	$65,000	$63,065	$62,000	$67,195	$74,300
Associate	92	$49,050	$64,040	$69,510	$72,351	$75,500	$81,203	$95,000
Full	180	$41,200	$73,180	$82,500	$100,456	$100,000	$137,031	$166,335

Table 22. Nine-Month Salaries, 11 Responses of 12 US CS Departments Ranked 13-24

Faculty Rank	# Faculty	Reported Salary Minimums			Average of all Salaries	Reported Salary Maximum		
		Minimum	Mean	Maximum		Minimum	Mean	Maximum
Assistant	40	$53,000	$59,985	$64,000	$62,779	$62,000	$65,412	$76,965
Associate	75	$54,241	$67,045	$78,151	$72,793	$70,800	$80,056	$94,950
Full	141	$64,672	$81,157	$110,367	$103,905	$112,510	$134,975	$212,500

Table 23. Nine-Month Salaries, 11 Responses of 12 US CS Departments Ranked 25-36

Faculty Rank	# Faculty	Reported Salary Minimums			Average of all Salaries	Reported Salary Maximum		
		Minimum	Mean	Maximum		Minimum	Mean	Maximum
Assistant	47	$53,000	$57,059	$60,500	$59,522	$57,161	$61,795	$68,600
Associate	74	$56,407	$64,162	$70,600	$69,248	$66,506	$73,812	$83,700
Full	109	$66,574	$75,602	$92,800	$94,210	$90,180	$123,527	$173,850

Table 24. Nine-Month Salaries, 78 Responses of 97 US CS Departments Ranked Higher than 36 or Unranked

Faculty Rank	# Faculty	Reported Salary Minimums			Average of all Salaries	Reported Salary Maximum		
		Minimum	Mean	Maximum		Minimum	Mean	Maximum
Assistant	284	$29,000	$53,204	$68,000	$56,064	$49,822	$59,048	$80,000
Associate	516	$33,000	$57,887	$82,500	$64,612	$52,436	$72,186	$97,200
Full	476	$41,000	$69,968	$110,000	$85,623	$60,850	$105,302	$170,000

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Table 25. Nine-Month Salaries, 6 Responses of 13 US CE Departments

Faculty Rank	# Faculty	Reported Salary Minimums			Average of all Salaries	Reported Salary Maximum		
		Minimum	Mean	Maximum		Minimum	Mean	Maximum
Assistant	18	$51,918	$55,541	$60,000	$57,897	$55,000	$61,238	$67,322
Associate	45	$56,000	$60,330	$64,000	$66,505	$59,000	$72,451	$78,785
Full	33	$59,000	$75,531	$83,500	$84,871	$75,298	$100,785	$132,700

Table 26. Twelve-Month Salaries, 13 Responses of 17 Canadian CS Departments (Canadian Dollars)

Faculty Rank	# Faculty	Reported Salary Minimums			Average of all Salaries	Reported Salary Maximum		
		Minimum	Mean	Maximum		Minimum	Mean	Maximum
Assistant	51	$40,868	$52,590	$69,689	$56,991	$48,000	$61,907	$75,314
Associate	132	$51,920	$61,428	$82,541	$70,457	$64,921	$81,868	$125,233
Full	149	$59,270	$76,062	$93,318	$91,415	$87,757	$112,523	$160,126

Table 27. Nine-Month Salaries, 110 Responses of 146 US CS and CE Departments

Faculty Rank	# Faculty	Reported Salary Minimums			Average of all Salaries	Reported Salary Maximum		
		Minimum	Mean	Maximum		Minimum	Mean	Maximum
Assistant	452	$29,000	$54,915	$68,000	$57,755	$49,822	$60,788	$80,000
Associate	802	$33,000	$59,994	$82,500	$66,542	$52,436	$73,816	$97,250
Full	939	$41,000	$72,243	$110,367	$89,566	$60,850	$112,708	$212,500

Table 28. Nine-Month Salaries for New Ph.D's, Responding US CS and CE Departments

Faculty Rank	# Faculty	Reported Salary Minimums			Average of all Salaries	Reported Salary Maximum		
		Minimum	Mean	Maximum		Minimum	Mean	Maximum
Tenure	30	$29,000	$51,037	$72,000	$53,011	$48,000	$60,315	$80,000
Researcher	13	$40,000	$48,006	$62,000	$50,666	$40,000	$54,612	$90,000
Postdoc	21	$15,000	$36,876	$52,000	$39,606	$25,000	$41,816	$56,375
Other	10	$30,000	$46,350	$60,000	$46,350	$30,000	$46,350	$60,000

major program elements:

1. **Presentations** by administration officials and senior corporate executives about the dimensions and importance of the problem.

2. **Problem-solving workshops** and presentations to exchange information about successful programs for retraining and recruiting workers.

3. A **preliminary report** of a colloborative study by the ITAA and a team of researchers from Virginia Polytechnic Institute (VPI). Like the original ITAA study, this one also focused on vacancies, but looked at a broader range of firms from user sectors as well as from the IT industry. This study raised the ante substantially, claiming a current shortage of 346,000 (129,000 in the IT industry and 217,000 in non-IT firms).

4. A **panel** that presented a surprisingly wide range of views on the issue, including some quite critical of the ITAA and Commerce Department reports.

The political and policy problem revolves around the concept of "shortage," which turns out to be a trickier question than most of us might think. A shortage of a commodity, i.e., gasoline, food, water, heating oil, and the like, would seem to be pretty apparent to the average person. People would go hungry, freeze, stand in lines, and so on. Of course, the signs of a worker shortage may be more subtle, but even more important. The concept of shortage, itself, turns out to be rather fragile in a market economy. What happens when supply falls short of demand? Prices go up. But, does a price increase automatically imply a

shortage? And isn't a price increase simply a signal to the market to produce more – just what we want to happen?

One problem, of course, is that labor markets are not like most commodity markets. One can't simply plant a larger crop of computer scientists and deliver when prices are high and store the excess in silos when prices fall. Delay times are very long, and signals imperfect, particularly when one talks about affecting the future career choices of youngsters. Even if market signals did get through clearly, the response time is in the scale of years. Much of the IT industry thinks in a time frame of months, even weeks. And if they cannot hire the people they need to move a project forward, they will simply choose another direction.

All of this means that the industry could very well perceive a serious problem while economists and statisticians express skepticism. "What is the metric?"

One can poke holes in counting reported vacancies, for example, as a surrogate for labor shortage. Many of the panelists listed such problems in criticizing the VPI study. Another measure might be salary inflation, but that is not always easy to document nationally either, since it gets caught up in issues of quality as well as quantity.

Worse, it raises a tough, perhaps the toughest, political problem. Since price is a measure of a commodity shortage, it is important to recall that, when prices move up or down, there are winners and losers. Certainly, if wages for computer scientists and engineers are escalating, why should they complain? In fact, many might think it's a pretty

good deal! Add to that a skepticism – one might call it cynicism, particularly on the part of some in the traditional engineering community and labor unions – of the motives and practices of employers, and one has the seeds of an opposing view. And, if the powerful labor unions get interested, it could make for some real difficulties.

Put most starkly, one speaker at the meeting accused the information industry of fabricating the whole shortage. Why? To create pressure for relaxing immigration laws and to encourage more workers to enter the profession. This, in the view of the speaker, would drive wages down in two ways: by increasing competition for vacancies and by allowing firms to lay off more expensive, older information workers.

Pretty strong stuff, but a politically powerful argument, not just because the labor unions could pick it up, but because, as shown in the UPS strike, the public at large has some uneasiness and sympathy for workers caught up in the consequences of technological change.

That sort of counterforce is less likely to remove the issue from the agenda; given the obvious importance of the information economy to the nation, the political system is likely to be very reluctant to simply dismiss an issue so strongly championed by the industry. Rather, it will force the search for policies to concentrate initiatives that are clearly focused on the workers, i.e., job protection, mid-career job retraining, and the like. One administration official at the meeting, for example, said that there was not support in the administration for relaxing immigration rules, a

move that labor unions and some engineering groups would strongly oppose.

Let's assume that, although metrics are fuzzy, we actually face a serious shortage of IT workers. Where do computer science and computer engineering departments fit in this debate? It's not yet completely clear.

Obviously, the graduate and undergraduate level CS&E majors will fill only a necessarily very small, but also a critically important, portion of the job vacancies, especially assuming the "true" shortage is anything like the numbers reported at the meeting. Possibly more demanding on the departments could be the growing need for minors and service courses across the campus. Some departments may find themselves playing an important role in job retraining programs. And, since one answer to a worker shortage problem is more productive engineering and analytical tools, there may well be implications for research.

To date, the computer science and engineering community has not participated very actively in the debate, although CRA provided substantial input to the OTP study and had representation at the Berkeley meeting. What may be necessary now is for the departments to begin discussing, for both the short term and long term, the following question: how will the projected changes in the information economy and work force needs affect the roles of computer science and computer engineering within their own institutions and within the communities they serve—be they local, regional, or national?

Association News

Effective Teaching and Academic Careers Workshops

CRA will again this year offer workshops on effective teaching and academic career development for people working in computing research. These workshops grew out of a series of highly successful workshops that were organized during the past several years by the CRA Committee on the Status of Women (CRA-W). People can sign up for either workshop, or receive a discount for signing up for both. The workshops are open to both men and women, and are primarily directed at advanced graduate students and junior faculty.

This year's Effective Teaching Workshop is organized by Tim Finin from the University of Maryland, Baltimore County, while the Academic Careers Workshop is organized by Dave Patterson of the University of California, Berkeley. Both are members of the CRA Board of Directors.

The Effective Teaching Workshop and the Academic Careers Workshop will be held in Madison, Wisconsin on Thursday, July 23 and Friday, July 24, 1998, respectively. The location coincides with a major meeting of the AAAI and several collocated meetings of groups interested in artificial intelligence, cognitive science and related topics. While there may be some examples used from the AI field in the CRA workshops, the focus will be on practical issues of interest to people beginning their academic career in computing, no matter what their field of specialty.

Topics at last year's Effective Teaching Workshop included preparing and delivering lectures, preparing and grading examinations, setting laboratory assignments, getting students to work effectively in group efforts, negotiating teaching assignments, and dealing with problem and gifted students.

Topics at last year's Academic Career Development Workshop included the tenure process, networking, selecting and managing a research program, obtaining research funding, and time management and family issues.

If you would like to see copies of the presentations given at last year's workshops, please view our website http://www.cra.org/Activities/workshops/academic_careers.html or http://www.cra.org/Activities/workshops/effective.html

For more information on this year's workshops or to receive registration information as it becomes available, contact kpeaks@cra.org.

In Brief - Committee Activities

Elections *(David Patterson)*

Nominations for CRA's Board of Directors closed on March 2. From the nominations received, the committee will select a slate of candidates. In mid-April, election ballots will be mailed to CRA members. The election results will be circulated in late May, and new Board members will begin their three-year terms on July 1.

Government Affairs
(Peter Freeman)

The Government Affairs Committee and others on the Board provide ongoing support to CRA staff in their Washington activities aimed at making sure that appropriate computing research policies are enacted. In January, Rick Weingarten represented CRA in a government-sponsored meeting on the information worker shortage (see Information Technology Worker Shortage Conference, page 1), and CRA will continue to follow this issue closely over the next few months. In the Senate, new NGI legislation is expected to be submitted, and CRA will prepare formal comments. In late February, Peter Freeman will represented CRA in a background meeting with Congressman Vernon Ehlers, head of the Science Policy Study in the Congress. Visits by Board members and others to Capitol Hill and other government offices in conjunction with the March Board meeting are being arranged. In May, CRA expects to testify at hearings on NSF appropria-

tions held by the House Committee on Appropriations.

CRA is involved in the planning of two upcoming meetings, both in Washington, DC. In April, CRA government affairs is co-sponsoring Net '98 with EDUCOM and other higher education groups. The meeting will focus on Federal networking policy. William Kennard, Chairman of the FCC, will deliver the keynote address. Also, Jim Foley is helping the USACM in its preparations for the Policy '98 conference in May.

Industrial *(William Gear)*

The Industrial Committee has completed a salary survey of industrial computer science research laboratories. Nine laboratories took part in this first such survey, which covered 655 scientists. The results were analyzed by CRA staff, and a statistical summary was distributed to companies that participated (using a format similar to that of the Taulbee Survey of academic salaries.)

Snowbird Conference

(James Foley and Mary Jane Irwin)

Committee plans for Snowbird '98 on July 26-28 in Snowbird, Utah are nearly finalized (see article, below.) Registration materials, including a printed information booklet, will be circulated shortly. Additional information and Snowbird program updates are available on the Web at http://www.cra.org/Activities/snowbird/snowbird98.html.

CRA Conference at Snowbird '98

If you're a computer science/engineering department chair or associate chair, director of graduate or undergraduate education, director of an industrial or government lab, a government or professional society leader in a field related to computing research, or someone whose professional interests lie in this area, Snowbird, Utah, is the place to be July 26-28, 1998. These are the dates of CRA's biennial Conference at Snowbird, so mark them down on your calendar and register without delay. From the special workshop for new departmental chairs on July 26 to the workshop *Understanding the Science Policy Process* in the final session on the afternoon of July 28, events are being planned that will pique your interest.

The CRA Conference at Snowbird '98 will in part focus on America's new deficit: the shortage of information technology workers. The rapidly changing labor market for "core" IT workers – computer programmers, systems analysts, and computer scientists and engineers – is having a major impact on our departments and labs. On the academic side, this is evident in the dramatic increases in majors/course enrollments, and in significantly greater competition for graduate

students and new faculty. In research labs, it is reflected in the increased competition for new employees, the higher salaries required to remain competitive, and the "eating our seed corn" phenomenon.

Industrial research directors will attend regular conference sessions and events, including a joint Academic/Industrial plenary session addressing the workforce issue, and workshops on both intellectual property issues and technology transfer. In addition, workshops are scheduled that are specifically oriented toward issues of concern to industry; for example, moving ideas from the research lab into the world of venture capital and managing industrial labs.

Dinner the first evening of the conference will feature a special guest speaker, Graham B. Spanier, President, Pennsylvania State University. Dr. Spanier will offer his perspective on Higher Education's Information Technology Agenda.

Plenary sessions will shed light on three current issues. The first, *Human Resources: Where Are We Now, Where Do We Need to Be*, will feature topics such as Ph.D. production projections and the revitalized academic job market, industry

opportunities and needs, and reversing the shrinking pipeline. This is a joint Academic/Industrial Snowbird session, and will be organized in a way that will be highly relevant to both groups.

The second plenary session, *Preparing for the 21st Century: The IT Revolution*, will feature experts who will address the central reorganization and the emergence of IT colleges, and the need to protect the CS/CE domain with the proliferation of "programming in discipline X" courses.

The final plenary, also of broad general interest, will feature a discussion of *Current Trends in Science Policy As It Affects CSE.*

In addition to plenary sessions, four workshops are planned, each offering three to five sessions that will run concurrently.

Of interest to both Academic/Industrial Snowbird participants is a special Science Policy Workshop, which will cover a range of topics related to improving the impact of the computing research community within Congress and the executive

branch. This will be conducted by Rick Weingarten, CRA's Director of Public Policy, and Peter Freeman, who chairs CRA's Government Affairs Committee.

The program committee, under the direction of Mary Jane Irwin, Pennsylvania State University, and Jim Foley, Mitsubishi Electric Research, is putting the final touches on what promises to be three days of activities that will provoke discussion and challenge the thinking of the community. Enjoy the pleasant surroundings of Utah's mountains in summer. Register now and take advantage of a discount for early sign-up.

For additional conference and registration information, including program updates, check out CRA's website at http://www.cra.org/Activities/snowbird/snowbird98.html. You may also register online at the previous address. The final program will appear in the May edition of *CRN*. Contact CRA via e-mail at snowbird@cra.org or call 202-234-2111 to request information booklets and registration forms.

Registration is available online at http://www.cra.org/Activities/snowbird/registration.html

Good News for Science in the Budget Prospectus

By Fred W. Weingarten

The administration had good news for science, for the National Science Foundation, and for computing research in its R&D budget request for FY 1999. Science Advisor John Gibbons said the requested increases in FY 99 funding were the "largest in history" for non-defense research. As expected, the largest beneficiary was NIH, which received an 8% increase of $1.1 billion, but NSF received a 10% raise of $344 million.

Computing research was mentioned by several speakers not only as an important field in itself, but as a major enabler of other areas of research. Both the Vice President and Harold Varmus, Director of NIH, noted that the major new opportunities in the health field are due in large part to contributions from federally funded research in areas such as computer science.

Two important overall trends were pointed out: 1) the shift from development to longer term research in the defense R&D budget, and 2) the proportionally large growth in university-based research funding (up 18%).

NSF's increases were substantial and across the board, with computing leading the pack with a 16.5% increase.

Table 1-A indicates the distribution within CISE. One complicating factor in looking at these numbers is a reorganization that took place last year, making it particularly difficult to draw meaning from the trends within divisions. This is not a new problem, though, since programs and funding areas are always being shuffled around among divisions and programs at some level.

In both infrastructure divisions (ACIR and ANIR) the research spending is scheduled to increase substantially. Networking research, in particular, will have a 72% increase over its current $8.38 million level.

CISE will also be increasing its investment in Knowledge and Distributed Intelligence by $14.12 million. This program ran into some resistance last year in the Senate Appropriations Committee . Although funds were ultimately put in the budget, NSF was asked not to proceed until a more detailed program plan was sent to Congress. NSF feels that those problems have been put behind them and is moving ahead on the initiative, both spending this year's money and asking for an increase next year.

One final point. Last year, the appropriations committees directed NSF to spend $23 million on networking connections and research this year from fees collected by NSI for domain name registrations. Those funds are now frozen by a court and their availability is uncertain. They are not reflected in the "Current" budget numbers for CISE—probably one reason the increase for ANIR looks unusually high.

	Current	Request	% Increase
	(In millions of $)		
CCR	60.7	67.5	11.3%
IIS	39.9	46.7	17.3%
EIA	60.7	72.1	18.9%
ACIR	76.9	81.6	6.2%
ANIR	46.1	63.1	36.9%

CISE Division definitions:
CCR
Computer Communications Research
IIS
Information and Intelligent Systems
EIA
Experimental and Integrative Activities
ACIR
Advanced Computational Infrastructure and Research
ANIR
Advanced Networking Infrastructure and Research

Changes in Higher Education Policy in the UK

By Martin Campbell-Kelly

In his election manifesto, Tony Blair promised that the new Labour government's top three priorities would be "education, education, education." On Thursday, May 1 last year the nation voted and by the early morning, as the votes were counted, it was clear that eighteen years of Tory rule were at an end. It was an historic landslide, the biggest that anyone of working age has ever experienced.

In university departments the following morning, academics were uncharacteristically cheerful: a little bleary-eyed from watching TV late into the night, but wearing the beatific smile of soldiers for whom the war was over. Overnight there was a surge of optimism in a profession that has been demoralized by nearly two decades of government opprobrium and budget cuts.

As I write, the honeymoon period of the new government is unquestionably over, and we are in something of a policy vacuum as the new administration evolves its strategy for higher education. Nonetheless the tone and realities of the new government are already clear. The government's tone is prescriptive rather than consensual, and there is little evidence so far of much of a dialog between the academy and government. As to realities, the new government – like Clinton's administration in the United States – is bound by the new consensus politics that favor a shift away from high taxation and state provision. For higher education, this means a move toward private purchase within a state-managed education service.

So far, the "education, education, education" rhetoric has mainly applied to children's schools. The Labour government has not been overly sympathetic to the higher education sector, which many Members of Parliament perceive as cosseted and elitist. When a policy emerges it will be oriented to lifetime learning, and widening access. Meanwhile the government is basing policy on the *Dearing Report.* The *Dearing Report,* which was published in July 1997, was produced by a committee of inquiry into higher education established by the previous administration, though with the support of all political parties. The government has focused on three main aspects of the report: the expansion of higher education, the assessment of teaching quality, and research – although this comes a poor third.

First, the government has committed to a massive expansion in higher education from the 30 percent of young adults currently entering the system to perhaps 45 percent. The expansion will target particularly low-income groups and ethnic minorities whose participation in higher education has been historically low. However, this is to be done with a much-reduced unit of resources. The spending constraints are particularly worrying for laboratory-based subjects, such as computing, where students are already often using somewhat antiquated equipment. In addition – for the first time in Britain – students will be required to contribute to their tuition fees. This will be set at a level of £1,000 a year starting next year, and students will be able to take out loans to cover the cost, to be repaid when they are earning a significant salary.

The long-term effect of students having to take out loans is presently unknown, but there is concern that it will tend to encourage high-earning, vocational subjects such as computing, business studies, and law, but disadvantage subjects with a less well-rewarded career outcome, such as drama, social work, or teaching. Students will typically graduate with a personal debt of £10,000 -15,000, which they must sooner or later discharge. In computer science, this is starting to translate into very high initial salary offers from cherry-picking employers – pre-eminently financial institutions – in order to attract the choicest graduating students. Sadly, these are the students we once attracted to postgraduate research and an academic career. Academics feel it cannot be right that the choice of an academic career is becoming ever more economically irrational.

The second point of the *Dearing Report* recommendation that the Blair government has taken on board is the establishment of a Quality Assurance Agency for Higher Education. This promises to be an unwelcome administrative burden that will involve onsite teaching assessment by a government-appointed inspectorate, with close examination of teaching methods and materials, and all aspects of the teacher-student interface. There is much that is wrong with university teaching, but hardly anyone in the profession believes that the way to fix things is by the appointment of a teaching police. This has been one of the more disappointing outcomes of the new government: we had hoped for a less oppressive regulatory environment, but there is a feeling that the new authority will be worse than the bureaucracy it replaced.

There is also much talk of introducing national standards in higher education, so that all degree programs will be regarded equal. This will theoretically equate a bachelor's degree in computer sciences from Cambridge University with a computing degree from a lowly institute of higher education. Few academics or employers think this makes sense; but so far the government is not listening to either of us.

The third issue concerning the academic community is research funding. For the last several years there has been intense pressure on universities to undertake high-quality research. As a result the competition for limited government funding is intense; only one in five applications secures funding, with a strong bias to elite institutions with a successful track record, so that most institutions are in practice doomed to disappointment. The *Dearing Report* recommended that the government should invest £1 billion to address infrastructure and equipment deficits, but so far only a fraction of that amount has been provided, pending a major policy review.

Nine months into a Labour government there is not much optimism left. As a colleague at my university remarked: the future holds the threat of the same, for less, forever. The only consolation is that at least most of us voted for this government, unlike its predecessor.

Martin Campbell-Kelly is Reader in computer science at the University of Warwick. The opinions expressed are entirely personal. He can be reached by e-mail, mck@dcs.warwick.ac.uk

Status of Women in Computer Science and Engineering Research
(Leah Jamieson and Jan Cuny)

The National Partnership for Advanced Computational Infrastructure (NPACI) and the National Computational Science Alliance (Alliance) – awardees in the NSF's Partnerships for Advanced Computational Infrastructure program – are coordinating outreach activities through the Education, Outreach, and Training Partnership for Advanced Computational Infrastructure (EOT-PACI). As part of this effort, EOT-PACI will be supporting activities of CRA's Committee on the Status of Women in Computing Research (CRA-W) and Coalition to Diversify Computing (CDC). Two

new CRA-W projects to be initiated with PACI support focus on under-graduates and research:

·**Conference Experiences for Women**. This program provides support for female undergraduates and beginning graduate students to attend a research conference with a faculty conference mentor. The experience of attending a research conference can be very motivating, and the interaction with conference attendees (particularly female faculty who can act as role models) is important in the decision to pursue a research career. The students will meet other attendees and will gain information about career development and networking. The project is being organized by Nancy Leveson (leveson@mit.edu) and Ruzena Bajcsy (bajcsy@central.cis.upenn.edu).

·**Undergraduate Research Teams.** At least seven undergraduate research teams of three female students each will be developed to focus on research problems as a group, led by a female researcher. The teams will come together for a semester, and results of their work will be posted on the CRA-W website and distributed as appropriate. This project is being organized by Sheila Castaneda (cast@keller.clarke.edu).

Surveys *(Gregory Andrews)*
The annual Taulbee Survey of Ph.D. granting departments has now been completed; final results are reported on pages 4 - 8 by the survey's coordinators, Stu Zweben and Dexter Kozen. The subcommittee on a new "departmental profiles" survey (chaired by Mirek Truszczynski) has put together a draft

that covers budgets, space, teaching loads, and graduate student support. The final draft will be presented to the CRA Board at its March meeting; the committee's goal is to conduct the survey later this spring.

Workshops *(David Patterson, Chair, Academic Careers)*
Workshops on effective teaching and academic career development are planned on July 23-24, 1998, in Madison, Wisconsin (see announcement, page 9). Speakers will include Jan Cuny (University of Oregon), Susan Eggers (University of Washington), Dave Patterson (University of California, Berkeley), Bobby Schnabel (University of Colorado), and Mary Jane Irwin (Pennsylvania State University).

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make sure that does not happen.

10 SIMPLE THINGS THAT CAN MAKE A DIFFERENCE

Here is a list of relatively simple things that we, as computer scientists, can do to support students with disabilities who have the ability and the desire to become computer scientists.

1. Design your own HTML documents in an accessible way. [See http://www.microsoft.com/enable/dev/web.htm and http://www.w3.org/WAI/References/#GUIDELINES for general information on accessible HTML documents; see http://www.w3.org/Style/css/#editors for information on cascading style

sheets; see http://www.wwwebit.com/magical-mist/ribbon.htm and http://www.cast.org/bobby/ for sites that check HTML documents for accessibility.]

2. Make sure your department's home page is accessible.

3. Pass this article on to advisors and people teaching introductory CS classes.

4. Encourage promising students that you come into contact with to major in computer science.

5. Become aware of what computer adaptive technology is available at your university.

6. If you have a student with a disability in your class or department, get some background information about relating to people with special needs. [See http://www.rit.edu/~easi/pubs/ezeticut.html

and/or contact your university's Services for Student's with Disabilities office.]

7. Make assignments/notes electronically accessible.

8. Use redundant multimedia effects where possible in presentations.

9. Use non-verbal and non-aural examples in lectures.

10.Treat students with disabilities with the same respect and consideration you use for other students.

FOR FURTHER INFORMATION

For further information on computer adaptive technology, see the following websites:
EASI (Equal Access to Software and Information) http://www.rit.edu/~easi/

Trace research and Development Center http://www.trace.wisc.edu
University of Washington, DOIT programhttp:??weber.u.washington. edu/~doit/

Dr. Joan M. Francioni is an Associate Professor and the Head of the Computer Science Department at the University of Southwestern Louisiana.
Dr. Francioni is also on the CRN Publications Committee, and the editor of the "Expanding the Pipeline" column. Dr. Francioni's main area of research involves debugging and performance tools for parallel programming. She has recently begun work in the field of assistive computer technology for people with disabilities. Send any questions you may have to jf@usl.edu.

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federal lawmakers wanted more specific information. Quoting the conferees' report: "The Foundation has not yet provided appropriate milestones or guideposts, to be accomplished in fiscal year 1998, and against which the agency can be measured in determining funding for fiscal year 1999. The conferees expect to receive references on such milestones and guideposts before the Foundation obligates any further funding for these programmatic areas." NSF, therefore, had to take the extra step of providing information before it could release the solicitation. Late in January, NSF received approval from the House and released the solicitation February 2.

NSF wants to see similar work emerge from the KDI grants as did with the LIS grants, so last year's awards are a useful comparison point for prospective applicants. Among the largest (institutional) grantees were: Carnegie Mellon University, awarded $3,242,900; Brown University, awarded $2,323,400; Northwestern University, awarded $2,156,075; and Johns Hopkins University, awarded $1,548,900. Grant projects included statistical reasoning, visualization and the analysis of

large-scale multiple-media data, computation in the visual domain, and reflective inquiry in knowledge-rich environments. (For a complete list of awards, projects, and institutions, see http://www.ehr.nsf.gov/lis/award97.htm.)

FY '98 Solicitation

As many as 75 projects could receive funding under KDI this year. The maximum amount available for any one project is $1 million annually for three years.

In its announcement, NSF stresses that it is looking for research that is "inherently multidisciplinary, or that, while lying within a single discipline, has clear impact on at least one other discipline." Below is an overview of the work NSF wants to see (to view the KDI announcement, including information regarding submission requirements, see http://www.nsf.gov/pubs/1998/nsf9855/nsf9855.htm)

Learning and Intelligent Systems – Based on the progress to date in cognitive science, computer science, and learning technologies, said McCloskey, "we are now ready to really move forward in our understanding of how the brain works, in particular, how people learn, and what constitutes intelligence; not

only in living systems, but also in engineered systems." The solicitation describes three "research emphases" which are, briefly: (1) the identification, analysis, and modeling of natural and artificial systems; (2) the development of learning tools and methods that utilize various concepts (e.g., behavioral, cognitive) with different technologies (interactive, collaborative, multisensory); and (3) the stimulation of basic research in learning and intelligence with the goal of applying the results to numerous situations.

Knowledge Networking – This area, said McCloskey, covers activities such as remote data collection, remote control instrumentation, distributed research groups in remote locations, as well as new techniques for data mining.

In the solicitation, several categories and subcategories of research are identified:
1. Foundational Research
· Processes and dynamics of distributed intelligence
· Managing heterogeneity and achieving interoperability
· Computational infrastructure, tools and environments
2. Prototype Development and Research

3. Ethical, Social and Behavioral Research
· Knowledge dissemination and sustainable use of knowledge networks
· Social integration and impacts of knowledge networking

New Computational Challenges – For this category, NSF defines two areas of study: (1) problems of scale and structure; and (2) interplay between computations and data.

The idea here, said McCloskey, "is that throughout science and engineering, there are a lot of problems that involve extremely complex computation, and, in fact, computational problems that were intractable until recently." Having both the raw computer power as well as some new computational methods will enable researchers to study complex interactions such as neuron activity in the brain.

One final question asked of McCloskey was whether there is specific timeline (e.g., five years, ten years) for KDI? "This is a major theme for the Foundation right now," says McCloskey. "Certainly it's expected to continue for a number of years."

NSF expects to issue another KDI solicitation in the near future with a proposal due date of February 1, 1999.

Numerical from Page 3

scientific theories. Current methodologies for these simulation tasks are not up to doing what we want. I describe a few areas that are barriers to further success:

· Interacting subsystems
· Multiple scales
· The effects of uncertainty

Computer simulations are organized in terms of systems constructed from interacting subsystems and components. As the complexity of the modeled object grows, we introduce hierarchical structure to the simulated system for the same reasons that we structure computer code. We have limited capacity to understand how large numbers of interacting components give rise to system behavior, especially when the components differ from one another. We deal with this problem by constraining the interactions, encapsulating subsystems as "input-output" devices whose internal dynamics do not contribute to system behavior. The success of this effort depends upon the extent to which these interactions are (in)sensitive to details within the components. For artificial systems, functional decomposition of systems into subsystems is a design principle. The spectacular success of VLSI technology rests in part on our ability to constrain the interactions among circuit components. We envision enormous design problems when the feature sizes of circuits decrease to the point that additional nonlinear interactions among nearby components become important. In other physical domains, stronger interactions among components are unavoidable but we still strive to produce reliable machinery. Reduced

order modeling, aggregation, and multiscale analysis are terms that we use to describe simulation technology for simplifying the complexity of subsystems while retaining their fidelity. Computer implementation of these methods is still in a primitive state, but mathematical theories provide a conceptual substrate for further progress.

Decomposition of natural systems into different "scales" is one of the central tasks in producing high-fidelity simulations. We seek to understand how macroscopic behavior results from physical laws that operate on smaller scales. For example, we would like to understand fracture in terms of atomistic properties of materials. Reducing all complex phenomena to atomic interactions is clearly a hopeless task. It is preposterous to model the effects of global climate change on natural populations and agriculture on an atomic scale. Doing it at all is problematic. Climate modeling itself is a horrendously difficult task, and natural variability precludes the formulation of precise laws of population dynamics. As we increase the resolution of computer models, the number of model parameters that must be measured or estimated grows. In most circumstances such measurements are too expensive or simply impossible. We don't even know what the most important variables are in determining the response of a population to shifts in climate. To obtain useful information from computer simulation of such systems, the computations must be robust to uncertainty within the model. It would be prudent to have systematic ways of evaluating the effects of uncertainty in model components upon system

behavior. Such methods hardly exist at this time.

Tackling the issues of scale, hierarchy, and uncertainty in simulations requires the creation of new theories that go well beyond existing ones. We also need significant improvements in more mature areas of numerical analysis. The cornerstone of simulation technology for continuous systems is the numerical integration of systems of ordinary differential equations. These algorithms are very robust, but they do not encompass the full range of systems that we seek to simulate. For example, models of control systems, electrical circuits, and mechanical mechanisms are often given as differential-algebraic equations in which constraint equations are added to systems of differential equations. Unlike differential equations, DAEs are not always self-consistent or solvable. Symbolic methods are applied to reduce DAEs to differential equations when this can be done explicitly, but that is not always possible. We lack algorithms that recognize when solutions to these systems break down and give diagnostic data in that event. In addition to DAEs, other generalizations of systems of ordinary differential equations are important for models. Digital control systems lead to hybrid models that combine discrete and continuous components. This has been an active research area for several years, but problem-solving environments that facilitate the design of hybrid systems are still rudimentary. Establishing an architecture that allows for the efficient description of hybrid systems and supports their simulation remains a research area that requires the joint efforts of computer scien-

tists, mathematicians, and engineers.

Beyond simulation, the analysis of models requires additional types of algorithms. Especially with natural systems, only partial information about system parameters can be obtained from measurements. Computational neuroscience attempts to model the nature of learning, memory, and computation in the human brain. We view the brain as a complex electrical circuit, but the complicated architecture of synaptic connections among neurons, the spatial distribution of membrane channels within the branched structure of neurons, and the highly nonlinear electrical properties of the neurons themselves obscure which components are critical to brain function. Our limited measurement capability makes identification of parameters for these models a task that must be guided by comparisons of model output with experimental data. The amount of computation needed to exhaustively explore parameter spaces grows exponentially with the number of parameters. Thus, we can only vary a small number of parameters independently of each other in simulation studies. This greatly complicates the task of fitting models to data. Indeed, the problems of fitting model parameters inhibit

USENIX from Page 3

ings of USENIX's refereed technical programs are published within 6 months of submission, distributed onsite at the conference, then made available to our members on the USENIX website and for purchase by others. Cash prizes are awarded for the best overall paper as well as the best student paper at each conference.

If you are interested in learning more about USENIX's many conferences, symposia, and workshops, please visit our website: http://www.usenix.org. There you will find posted the Calls for Submissions for our upcoming events as they are announced. The Calls give detailed instruction to researchers about submitting their new work for consideration by the Program Committee developing each event.

USENIX and its members value highly the research in the computing systems arena that is generated in colleges and universities. We know computer science faculty members work hard to provide their students with opportunities for technical enrichment, professional development and financial support for their research projects.

Recognizing the importance of this work, USENIX generously funds an array of programs to encourage students' professional development. "USENIX has always provided a unique environment for students: one in which they can be heard, in which they can learn, and in which they can grow," says Margo Seltzer, USENIX scholastic committee member and professor of computer science at Harvard. "We are enthusiastically looking forward to providing these opportunities to an ever-increasing group of students."

USENIX is proud to offer the following programs for full-time students. Detailed information is available at our website: http://www.usenix.org/students.

· Research Grants
· Undergraduate Software Projects Grants
· Scholarships
· Very low student fees for USENIX technical and tutorial programs
· Stipends for travel and housing for students at USENIX events
· Memberships in USENIX at just $25 affords students the opportunity to participate in the advanced computing community and receive USENIX publications.

USENIX student scholarships typically cover some or all of a student's expenses including tuition, supplies, and stipend. A generous annual budget provides for funding of student research projects and student software projects; i.e. projects which allow students to perform the software engineering necessary to take an undergraduate course software project to an actual, robust, and portable software package useful to the community. With research grants, we also pre-approve student travel stipends so the student recipients can attend a USENIX conference and present the results of their work. Student contributions to conference programs are encouraged with cash awards for the best paper authored by a student.

Both students and their faculty advisors appreciate our proposal process for scholarships and research grants, which is known for being common-sensical and free of fuss. "One of the things I love about USENIX is that there's so little paperwork involved," said Mary Baker, a professor at Stanford University where her student was a recent scholarship recipient. "A scholarship where the student and

advisor don't have to dig up transcripts back to kindergarten, and such, is a special thing in this world."

Another contribution in the area of support for undergraduate education of which we at USENIX are particularly proud is the USENIX Association's $250,000 endowment to the College Fund (formerly United Negro College Fund). The endowment will fund an annual scholarship to encourage minority students to study computer science. On the day the scholarship was announced USENIX President Andrew Hume expressed the Association's feelings, "Historically and currently, minorities are underrepresented in the technical community that is the core of USENIX's membership. USENIX is delighted to make a substantial contribution towards increasing minority participation in the field of computer science."

Our conferences and workshops, the publication of refereed papers, and our programs for support of student development and participation are just some of the many ways in which the USENIX Association achieves the mission for which it was founded.

Professional Opportunities

Bowdoin College
Department of Computer Science

The Department of Computer Science at Bowdoin College invites applications for a full-time tenure-track position at the rank of assistant professor to begin in the Fall of 1998. Ph.D. preferred, ABD considered. The successful candidate will be expected to teach four courses per year at the introductory, core, and advanced undergraduate levels. Preference will be given to strong candidates with interests in artificial intelligence or cognitive science. Applicants must possess a commitment to undergraduate education and demonstrate the potential to develop a productive research program.

Bowdoin is a highly selective, coeducational, liberal arts college of 1550 students located two hours north of Boston, close to Portland, along the Maine coast in a community of 24,000. Departmental lab facilities include Macintoshes for the introductory courses, and a network of Linux machines for use by students in intermediate and advanced courses. In September 1999 the department will move into a completely renovated building. The building will be shared with the Mathematics and Physics departments, with whom our department maintains close and collegial relationships. Further information about Bowdoin and the department is available at www.bowdoin.edu

Applicants should send a letter of application, a curriculum vitae, statements of teaching philosophy and research interests, and arrange for three reference letters to be sent to:

David Garnick, Chair
Department of Computer Science
8650 College Station
Brunswick, ME 04011-8486
Questions can be directed by email to garnick@bowdoin.edu

Consideration of applications will begin February 1, and continue until the position is filled. Bowdoin is committed to equal opportunity through affirmative action. Women and members of minority groups are encouraged to apply.

Brandeis University
Department of Computer Science

The Computer Science Department of Brandeis University invites applications for the position of Assistant Professor of Computer Science, to begin September 1998.

We are seeking candidates with research interests in building systems, in such areas as parallel or distributed computing, operating systems, data bases, HCI, computer graphics, scientific visualization, multimedia, networks and applications to the web. All applicants are expected to have a completed Ph.D. by September 1, 1998 in Computer Science / Engineering, an outstanding research record and documentation of strong teaching.

The Computer Science Department is part of the Volen Center for Complex Systems, dedicated to interdisciplinary research in science; the Center includes faculty from biology, psychology, linguistics, biochemistry, chemistry and physics. For additional information visit our web page at http://www.cs.brandeis.edu.

Brandeis University is an equal opportunity / affirmative action employer; women and minorities are encouraged to apply.

Candidates are encouraged to apply as soon as possible; applications will be reviewed on an ongoing basis until the position is filled. Please send by surface mail (NOT by fax or e-mail) a curriculum vitae, your two best publications and at least three letters of reference to:

Prof. Richard Alterman, Search Committee Chair
Computer Science Department
Brandeis University
Waltham, MA 02254
Phone: 617-736-2703
Fax: 617-736-2741
E-mail: search @cs.brandeis.edu

California Institute of Technology
Computer Science Department

The California Institute of Technology invites applicants for a tenure-track position from persons with promise for innovative research and teaching. Qualified applicants may be considered at the associate or full professor level. Initial junior faculty appointment is normally for four years and is contingent upon completion of Ph.D. Please send a resume, list of publications, copies of your best publications and names of at least three references to:

Mani Chandy, Chairman
Computer Science Steering Committee
Caltech 256-80
Pasadena, CA 91125.
Caltech is an Equal Opportunity/Affirmative Action Employer. Women and minorities are encouraged to apply.

Case Western Reserve University
Case School of Engineering
Faculty Positions in Computer Engineering and Science

The Case School of Engineering invites applications at all ranks for tenure-track or tenured positions in the Department of Computer Engineering and Science, starting in the 1997-1998 academic year. Applicants should have a Ph.D. in Computer Engineering, Computer Science or a closely related field. Demonstrated excellence in both research and teaching is required. Candidates in all areas are encouraged to apply. However, the areas of computer architecture, graphical interface design, concurrent programming, distributed computer systems and networks, virtual reality, software development environments, design automation, and parallel computing are of most interest.

Salary will be commensurate with appointment rank and qualifications of the applicant. Case Western Reserve University is a private, research university located in the University Circle area of Cleveland, Ohio. The University Circle area is a unique region of Cleveland containing numerous schools, museums, and other cultural organizations. For instance, Severance Hall, the home of the Cleveland Orchestra, is within 100 yards of the university's main administration building.

Applications should be directed to: Faculty Search Committee, 406 Olin, Case Western Reserve University, 10900 Euclid Ave., Cleveland, OH 44106-7071

A complete application shall contain a curriculum vitae, the names and addresses of at least three references, and a statement of research and teaching objectives. The search committee will make its decisions based on its estimation of the candidates ability to perform excellent research and effective teaching.

Case Western Reserve University is an Equal Opportunity Affirmative Action Employer. Women and Minorities are encouraged to apply.

Case Western Reserve University
Case School of Engineering
The Nord Professorship
A Leadership Position in Information Technology

The Case School of Engineering invites applications and nominations for the appointment of a nationally recognized scholar and researcher to hold the Nord Professorship in the Department of Computer Engineering and Science. The professorship will provide the outstanding professional opportunities: a highly competitive compensation package, plus additional funds for travel, graduate student support, and equipment. Qualifications include the ability to develop and guide a leading program of sponsored research and undergraduate and graduate education in areas of information technology, including networking, communications, multimedia, etc. The successful candidate will meet the criteria for a senior faculty appointment.

CWRU is a private, highly selective research university with a full range of undergraduate, graduate, and professional programs. Its location, University Circle, is remarkable: a park-like area four miles east of the center of Cleveland that is home to more than 40 educational, cultural, and health-care institutions, including the Cleveland Orchestra, the Cleveland Museum of Art, and University Hospitals of Cleveland. CWRU's student body of 9,700, including about 6,100 students in graduate and advanced professional programs, has access to staff and resources at many of the neighboring institutions in University Circle.

The breadth of interest in information technology on the campus will provide the Nord Professor with opportunities for interaction with a wide range of disciplines, aided by the most advanced and ubiquitous fiber-optic network on any campus in the nation. In addition to collaboration with other engineering departments, IT links are likely with colleagues in fields such as management, medicine, nursing, the physical sciences, and law, and with the University's information services and library systems.

Applications and nominations, including curricula vitae and the names of at least three references, should be sent to:

Dr. Robert Edwards, Search Committee Chair
c/o Department of Computer Engineering & Science
Olin Building, Room 407
CWRU 10900 Euclid Avenue
Cleveland, OH 44106-7071
The committee will begin reviewing submissions in April, 1997 and will continue until the position is filled.

CWRU is an Affirmative Action/Equal Opportunity Employer. Women and minorities are encouraged to apply.

Colgate University
Department of Computer Science

Colgate University invites applications for a two year visiting position starting in the Fall 1998. A Ph.D. degree or equivalent with strong interest in both teaching and research are expected. Applicants are sought from all areas of computer science with preference given to candidates with expertise in operating systems.

Colgate University is a highly competitive liberal arts university situated in upstate New York. The university is committed to promoting excellence in both teaching and research.

Review of applications will begin February 15 and continue until the position is filled. Resumes and three letters of recommendation should be sent to:

Chair, Faculty Search Committee
Department of Computer Science
Colgate University
13 Oak Drive
Hamilton, New York 13346
Colgate University is an equal opportunity/affirmative action employer. Women and minorities are encouraged to apply.

Computists International
Computists' Communique

For careers beyond programming: research jobs, competitions, AI/industry news, announcements. <www.computists.com>, laws@computists.com.

Florida International University
School of Computer Science

Applications are invited for tenure track faculty positions at the level of Assistant Professor. A Ph.D. in computer science or related area is required. Candidates are sought in all areas of computer science. The School is currently strong in database, distributed computing, software engineering, and theory. At least one new hire will be affiliated with our High Performance Database Research Center, which is primarily sponsored by NASA.

Successful candidates must be committed to excellence in teaching at both the graduate and the undergraduate levels, as well as developing a high-quality research program. Our salary and benefits package is highly competitive.

The School of Computer Science is a designated program of excellence at F.I.U. and enjoys strong support from the University administration. It has 25 faculty members and offers BS, MS, and Ph.D. degrees in Computer Science. The current enrollment is approximately 600 undergraduate majors and 81 graduate students. The School operates a large network of state-of-the-art workstations and also shares in the significant computing resources maintained on campus.

Applications, including a letter of interest, curriculum vitae, e-mail address, and the names of three references, should be sent to: Chairperson, Recruitment Committee, School of Computer Science, Florida International University, University Park, Miami, FL 33199. Applications must be postmarked no later than February 25, 1998. Further information can be obtained by phone at 305-348-2744, via e-mail from recruit@scs.fiu.edu, or on the WWW at http://www.cs.fiu.edu.

Florida International University is a member of the State University System of Florida and is an equal opportunity/affirmative action/equal access employer.

Florida State University
Department of Computer Science

The department invites applications for tenure-track faculty positions. The department is entering a period that will require significant faculty growth. New recruits will have the opportunity to help shape the department's future. We are primarily looking for people at the Assistant Professor level, but will consider strong candidates at any level. Applicants are required to have completed a Ph.D. in computer science, computer engineering or a closely related field by the date of the appointment.

Exceptionally qualified individuals in any area of computer science are encouraged to apply. Priority will be given to applicants with research strengths that will support the university's program in computational science, the department's initiative in trusted systems and the MS tracks in software engineering and computer and network system administration. Examples of specific topics of interest include software engineering, real-time systems, operating systems, databases, fault tolerance and scientific visualization. Selection will be based on evidence of outstanding research accomplishments and teaching ability.

Please send a resume and arrange for at least three letters of reference to be sent to the following address.

Faculty Search Committee
Computer Science Department
PO Box 4530
Florida State University
Tallahassee, FL 32306-4530
The Florida State University is an Equal Opportunity/Affirmative Action employer that encourages applications from minorities and women and complies with the Americans with Disabilities Act. It is a public records agency pursuant to Chapter 119, Florida Statutes.

The university is located in Tallahassee, a small city of approximately 120,000 with excellent public schools and affordable housing and has approximately 30,000 students. The department offers degrees at the BS, MS, and Ph.D. levels. Further information about the university and the department can be found at the website: www.cs.fsu.edu.

Grinnell College
Department of Mathematics and Computer Science
Visiting Assistant Professor of Computer Science

One-year leave replacement position in Computer Science starting August, 1998. Assistant Professor (Ph.D.) preferred, Instructor (ABD) possible. To apply, send curriculum vitae, copies of transcripts, three letters of recommendation and a statement describing your interest in teaching and research in an undergraduate liberal-arts environment that emphasizes close interaction with students. Address applications to: Computer Science Search Committee, Department of Mathematics and Computer Science, Grinnell College, Grinnell, IA 50112. E-mail: walker@math.grin.edu; Fax: 515-269-4984. For more information, see http://www.math.grin.edu/1998-cs.html. Review of applications will begin March 15, 1998, and will continue until the position is filled.

Grinnell College, an affirmative action employer, encourages applications from women and persons of color and considers applications without regard to gender, race, color, creed, age, national or ethnic origin, disability, or sexual orientation.

Professional Opportunities

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Harvey Mudd College
Computer Science Department
Assistant Professor of Computer Science

Claremont, California

The Computer Science Department of Harvey Mudd College (http://www.hmc.edu) intends to appoint a tenure-track Assistant Professor of Computer Science, to start September 1, 1998. While applicants are invited from all areas of computer science, applicants teaching and conducting research in one or more of the following are preferred: distributed systems and algorithms, software engineering, artificial intelligence, computer graphics, computer architecture and operating systems.

The successful candidate will have completed the Ph.D. in Computer Science by the time of appointment, and is expected to devote attention to excellence in teaching, as well as to the development of a research program.

Harvey Mudd College is a highly-selective undergraduate college (650 students) oriented toward science, mathematics, and engineering. The Computer Science Department is the newest major at the college, now offering a wide array of courses in both foundations and advanced topics in computer science.

The department's Computer Science Clinic provides a strong link to the industrial community in the form of year-long student projects. The successful applicant is expected to become an active and enthusiastic participant as a Clinic supervisor. Qualified students also engage in research and publication with faculty members.

Claremont is a pleasant suburban community in the foothills of the beautiful San Gabriel mountains, near the boundary between Los Angeles and San Bernardino counties. It is a 25-minute drive from Pasadena and Orange County, with access to the cultural attractions of Los Angeles, as well as ocean beaches and mountain ski areas within a 45 minute drive.

Applicants should respond with a curriculum vitae, a statement regarding teaching and research philosophy or plan, and supporting materials such as reprints. Concurrently, please request three references to write to us directly. Consideration of candidates will begin January 30, 1998.

E-mail applications and reference letters (plain text is preferred) are accepted: keller@cs.hmc.edu.

Professor Robert Keller, Chair
Computer Science Department
Harvey Mudd College
301 E. Twelfth Street
Claremont, CA 91711
Harvey Mudd College is an Equal Opportunity Employer. Applications from groups typically underrepresented in college computer science faculties are strongly encouraged.

Haverford College
Department of Computer Science

Applications are invited for a one-year visiting position 1998-1999. Teaching experience is expected and a Ph.D. preferred. Duties will include four courses (two per semester with labs) among which are introductory courses (in C++) and upper-level operating systems. Class sizes are typically small (about 10-30 students).

Haverford is a highly selective liberal-arts college boasting very strong students and an Honor Code. For more information see our Webpage : http://www.haverford.edu/cmsc/search.html

Please send curriculum vitae, along with letters of recommendations that can attest to teaching ability to:

Professor Steven Lindell
Computer Science Department
Haverford College
Haverford, PA 19041
E-mail inquiries should be directed to kmcgoldr@haverford.edu.
Haverford College is an AA/EOE

Kent State University
Department of Mathematics & Computer Science
Distinguished Professor of Computer Science

The Department of Mathematics and Computer Science invites applications and nominations for the position of Distinguished Professor of Computer Science. While our current principal area of interest is parallel and distributed computation and networking, outstanding candidates in all areas will be considered. This position, which resulted from an initiative by the Ohio Board of Regents to strengthen PhD computer science programs in Ohio, is intended to enhance the quality and visibility of research activities in the department as well as to promote collaboration between the computer science doctoral programs in Ohio and with industry. In addition to startup funds, the position includes ongoing research funding. A successful candidate will be expected to interact effectively with existing faculty and to help in shaping the future research directions of the department.

The department offers BS, MA, MS and Ph.D. degrees in computer science, together with BS, MS and Ph.D. degrees in applied and pure mathematics. The computer science program has 14 faculty, over 90 graduate and over 200 undergraduate students, and is experiencing growth in student numbers. In broad terms, the faculty areas of research lie in massively parallel and distributed computation; numerical and scientific computation, modeling, and visualization; symbolic computation; networking and distributed operating systems; theoretical computer science; and artificial intelligence and image processing. The department has well-equipped research and teaching laboratories comprising high performance UNIX workstations and PCs connected by ATM, Fibre Channel and 100VGAnyLAN networks. The department recently moved to a new building and expects to increase its equipment holdings and staff considerably in the near future as a result of the state initiative.

Letters of nomination or application letters together with a resume and the names of five references should be sent to the Distinguished Chair in Computer Science Search Committee, Department of Mathematics and Computer Science, Kent State University, Kent, Ohio 44242, USA, Fax 330-672-7824. Nominations and applications may be submitted via e-mail to distinguished@mcs.kent.edu. The search committee will begin to consider applications immediately and will continue until the position is filled.

Kent State University is an Affirmative Action/ Equal Opportunity Employer. Additional information about the Computer Science program at KSU is available at http://www.mcs.kent.edu/cs.

Kent State University
Department of Mathematics & Computer Science
Faculty Position in Operating Systems

The Department of Mathematics and Computer Science invites applications for a tenure-track faculty position at the assistant professor level in the area of operating systems. This position is viewed as enhancing or complementing the department's existing expertise in parallel and distributed computing, and networking, and will include appropriate startup funds for the establishment of a laboratory.

The department offers BS, MA, MS and Ph.D. degrees in computer science, together with BS, MS and Ph.D. degrees in applied and pure mathematics. The computer science program has 14 faculty, over 90 graduate and over 200 undergraduate students, and is experiencing growth in student numbers. In broad terms, the faculty areas of research lie in massively parallel and distributed computation; numerical and scientific computation, modeling, and visualization; symbolic computation; networking and distributed operating systems; theoretical computer science; and artificial intelligence and image processing. The department has well-equipped research and teaching laboratories comprising high performance UNIX workstations and PCs connected by ATM, Fibre Channel and 100VGAnyLAN networks, which were acquired under recent Ohio Board of Regents and NSF funding initiatives. The departmental research networks are connected to the recently created campus ATM backbone,and to OCARnet, a state-wide ATM testbed linking several Ohio computer science departments and the Ohio Supercomputer Center. The Department recently moved to a new building and expects to increase its equipment holdings and staff considerably in the near future as a result of an ongoing state initiative in computer science.

Applicants should submit a cover letter and a resume and should arrange to have three letters of recommendation sent to the Computer Science Search Committee, Department of Mathematics and Computer Science, Kent State University, Kent, Ohio 44242, USA, FAX 330-672-7824. Applications may be submitted via e-mail to cs-pos@mcs.kent.edu. The search committee will begin to consider applications immediately, and will continue until the position is filled.

Kent State University is an Affirmative Action/ Equal Opportunity Employer. Additional information about the Computer Science program at KSU is available at http://www.mcs.kent.edu/cs.

Mankato State University
Department of Computer and Information Sciences

We invite applications for three full-time, tenure-track assistant professor positions. Applicants should have a doctorate degree in MIS, Computer Science or Information Systems by July 31,1998 and have a strong commitment to research and teaching. Areas of interest are data communications, client/server, software engineering, COBOL programming and systems analysis and design.

Send a curriculum vitae and letter of application that addresses strengths relative to the position, and the name, address and phone number of three references able to address the required qualifications to: Chair, Search Committee, Mankato State University, Dept. of Computer and Information Sciences, MSU 225, P.O. Box 8400, Mankato, MN 56002-8400 or earchmis@epsilon.cs.mankato.msus.edu. Priority will be given to applications received by March 1,1998.

Mankato State University is an affirmative action/equal opportunity educator and employer.

Mississippi State University
Department of Computer Science

The Department has openings for tenure-track faculty at the Assistant or Associate Professor level. A Ph.D. in computer science or a closely related field is required. Areas of interest are a) computer graphics, scientific visualization, and geometric modeling, and b) software engineering, with expertise in distributed computing, databases, or high performance computing considered desirable.

The Department has 18 faculty positions. The doctoral program, soon to enter its tenth year, includes 24 Ph.D. students. Three new faculty have received NSF CAREER awards. Department research expenditures for '96-97 exceeded $1,000,000, exclusive of involvement at associated research centers.

Faculty and graduate students work with several on-campus research centers, including an NSF Engineering Research Center (http:// www.erc.msstate.edu) specializing in high-performance scientific computing, and the Diagnostic Instrumentation and Analysis Laboratory (http://www.msstate.edu/Dept/DIAL), specializing in complex instrumentation problems for severe environmental situations. Additional funding comes from NASA, NSF, ONR, DARPA, USDA, government laboratories and centers, and industries. MSU is among the top 100 universities receiving federal funding for research in science and engineering and is ranked third in the Southeast for engineering research funding. Review of applications begins February 1, 1998.

For more information, see http:// www.cs.msstate.edu/ANNOUNCEMENTS/ facpos.htm. MSU is an AA/EO employer.

Oklahoma State University
Computer Science Department

Applications are invited for an anticipated full-time position at the Assistant Professor level. The term of initial appointment will begin in Fall, 1998.

The Oklahoma State University Computer Science Department is seeking applications from qualified candidates with research experience in all areas of Computer Science. Preference will be given to candidates with research experience in computer networks. A Ph.D. or D.Sc. in Computer Science or a closely related area is required.

The department is committed strongly to the goal of excellence in both research and teaching. The department offers a full range of undergraduate and graduate courses leading to BS, MS, Ph.D., and Ed.D. degrees. There are currently more than 200 undergraduate students and more than 150 graduate students enrolled in the department.

Stillwater is a small, attractive university city of about 38,000, located on the prairie in north-central Oklahoma. Stillwater is 65 miles west of Tulsa and 65 miles north of Oklahoma City. There are numerous cultural activities within a two-hour drive of Stillwater. The Oklahoma State University campus is one of considerable beauty with modified Georgian architecture.

Oklahoma State University encourages applications from qualified women, minorities and persons with disabilities. Please send curriculum vitae and names of three references to:

G.E. Hedrick, Chair
Faculty Search Committee
Computer Science Department
Oklahoma State University
Stillwater, OK 74078-1053
Telephone: 405-744-5668
Fax: 405-744-9097
E-mail: faculty-search@cs.okstate.edu
WWW:http://www.cs.okstate.edu/search.
Review of applications will begin February 1, 1998. However, applications will be accepted until the position has been filled. Oklahoma State University is an Affirmative Action/Equal Opportunity Employer.

Oregon Graduate Institute of Science and Technology
Department of Computer Science and Engineering

The department anticipates a position in the immediate future at the assistant or associate professor level in areas of software engineering, networking, multi-media, mobile computing, human computer interaction, systems languages, databases, or speech recognition. Applicants should have prior faculty or postdoctoral research and teaching experience, although exceptional candidates who are anticipating completion of a Ph.D. may also be considered.

Located near Portland, in Oregon's high tech corridor, OGI provides outstanding graduate and professional education and conducts internationally acclaimed research in science and technology. This combination of world-class research and education is significant in it's impact on local and global industry, creating new standards of excellence in both familiar and evolving areas of study. OGI is a private graduate school with no undergraduate programs. Faculty are responsible and rewarded for their contributions to relevant research and education. There is no tenure. More information can be found at http://www.cse.ogi.edu.

To apply, send a brief description of research interests, the names of at least three references and a resume with a list of publications to Chair, Recruiting Committee, Department of Computer Science and Engineering, Oregon Graduate

Institute, PO Box 91000, Portland, Oregon 97291-1000. E-mail: csedept@cse.ogi.edu.

OGI is an equal opportunity employer and particularly welcomes applications from women and minority candidates. Appointment is subject to the availability of funding.

Oregon Graduate Institute of Science and Technology
Department of Electrical and Computer Engineering
Gordon and Betty Moore Chair

The Department of Electrical and Computer Engineering is starting a major rebuilding process. We have two chair positions and two junior faculty positions open - the most prestigious being the Gordon and Betty Moore Chair Professor, recently endowed by the co-founder of Intel. For this position, we seek a senior person to lead the development of a research program in VLSI design or semiconductor technology. The second chair is the Doug Strain Chair Professor endowed by the founder of Electro-Scientific Instruments - this chair is intended to support a new department head to lead the department rebuilding process. We also have two junior faculty positions to fill, both Assistant and Associate Professor grades. Since we are in the midst of a major expansion, for these positions we are open to specialties in a broad area, though preference will be given to VLSI, semiconductors and image processing.

Candidates must have a Ph.D. degree and must have demonstrated a strong capability for independent, fundable and publishable research. Our graduate education program is an important part of OGI's mission, so candidates must also be successful teachers. Oregon Graduate Institute is located in the heart of Oregon's Silicon Forest, surrounded by a number of world-class semiconductor companies. In addition, we are home to Tektronix, Sequent, and Mentor Graphics. Oregon is Intel's largest site and is the home of the Intel Architecture Labs and the Pentium Pro development group. The Tektronix Video and Networks product group is located nearby.

Oregon Graduate Institute, http://www.ogi.edu, is small, dynamic, and entrepreneurial. We seek applicants who are as dynamic and entrepreneurial as we are. Join us in the splendor of the great Pacific Northwest in building a world class institution. Applicants should send a complete resume to the Department Recruiting Committee, Electrical and Computer Engineering Department, Oregon Graduate Institute, P.O. Box 91000, Portland, OR 97291-1000 USA, or e-mail to search@ece.ogi.edu.

We strongly encourage application by female and minority candidates. Oregon Graduate Institute is an equal opportunity employer.

Purdue University
School of Electrical and Computer Engineering

Purdue University School of Electrical and Computer Engineering seeks outstanding candidates in computer engineering for research and teaching in the following areas: artificial intelligence, computer architecture, computer networks, operating systems, software engineering, VLSI and CAD. Strong candidates in other areas of computer engineering are also encouraged to apply. Openings are for tenure-track faculty at all levels.

Applicants will be required to have a doctorate degree. Send a resume, including a statement of research and teaching interests and a list of at least three references, to: Head, School of Electrical and Computer Engineering, Purdue University, 1285 EE Building, West Lafayette, IN 47907-1285.

Applications will be considered as they are received. Purdue University is an Equal Opportunity/Affirmative Action employer. (68-97)

Southern Methodist University
Computer Science and Engineering Department

Southern Methodist University invites nominations and applications for the position of Professor and Chair of its Computer Science and Engineering Department. Candidates must have an earned doctorate in Computer Science, Computer Engineering or a closely related field with credentials to qualify for the rank of full professor. Applicants must have a strong record in teaching, research and scholarly activities, and demonstrated ability in obtaining sponsored research from government agencies and industry. The successful candidate must have excellent management and communication skills, a solid commitment to excellence in undergraduate and graduate education, and be strongly committed tin promoting faculty research activities.

SMU is a private university dedicated to academic excellence. Located in Dallas, SMU maintains a moderate size of about 10,000 students. The Computer Science and Engineering Department resides within the School of Engineering and Applied Science. The department currently has 14 faculty members, with two open positions. It presents a balanced program of research and education at all levels and offers BS, MS and Ph.D. degrees.

Faculty research concentrations are in artificial intelligence, computational programming, computer arithmetic, computer networks, database systems, distributed operating systems, parallel processing, software engineering, as well as other related areas. The department has more than 160 undergraduate

students, 120 students in its traditional graduate programs, and about 160 graduate students in its popular Software Engineering program. Additional information is provided at: www.seas.smu.edu/cse. To learn more about the rich cultural environment of SMU, please see: www.smu.edu.

The Dallas/Fort Worth area, one of the top three high-tech industrial centers in the country, has the largest concentration of telecommunications corporations in the US; providing an ideal supportive environment for rapid growth and the development of active collaborative relations with industry. The appointee is expected to significantly foster and increase such collaborations. Dallas/Fort Worth is a multifaceted business and engineering community, offering exceptional museums, diverse cultural attractions and a vibrant economy.

Interested and qualified individuals should send a complete resume, including a one-page statement of research interests and accomplishments to: Dr. Jerry D. Gibson, Chair, CSE Chair Search Committee, School of Engineering and Applied Science, SMU P.O. Box 750331, Dallas, TX 75275-0331, or e-mail: gibson@seas.smu.edu. To ensure full consideration, applications must be postmarked by March 31, 1998, however, the search committee will continue to accept and review applications until the position is filled.

All applicants will be notified of the final employment decision. SMU is an affirmative action, equal opportunity, Title IX employer. The University particularly encourages the candidacies of women, and persons with disabilities.

Stanford University
Electrical Engineering and Computer Science

Stanford University, departments of Electrical Engineering and Computer Science seek candidates for a tenure-track appointment in the area of systems and control, broadly defined, with an emphasis on topics at the boundary between continuous and discrete systems, e.g., hybrid systems, discrete-event systems, and control of networks. The appointment will be made at the level of Assistant Professor. An earned Ph.D., evidence of the ability to pursue independent research and a strong commitment to graduate and undergraduate teaching are required. The appointee will be expected to develop an innovative program of research that is coupled to emerging opportunities such as the development of theory and tools for embedded control, hybrid systems, network control, control of systems in an asynchronous, distributed environment, etc. She or he will be expected to teach both undergraduate and graduate courses in systems and control and related areas.

Applications should be submitted to Professor Stephen Boyd, Search Committee Chair, Department of Electrical Engineering, Durand 111, Stanford University, Stanford, CA 94305. The application should include a brief research and teaching plan, a resume including publications list, a copy of a graduate level transcript, and the names of at least five references.

The deadline for receipt of applications is March 31, 1998. Stanford University is an Affirmative Action employer seeking to increase representation of minorities and women among its faculty.

Syracuse University
Electrical Engineering and Computer Science
Three positions available

The department invites applications for:
(1) a tenured senior faculty position in RF/Wireless systems with emphasis in hardware, design and fabrication
(2) a tenure-track junior faculty position in software with a focus on distributed object technologies and system design
(3) a temporary-term, non-tenure- track faculty member to teach computer engineering courses

For all positions a doctorate in a field appropriate to the area is required. Submit a curriculum vitae, research and teaching statements, copies of selected publications, and have three reference letters sent to: Faculty Search Committee, Department of Electrical Engineering and Computer Science, 121 Link Hall, Syracuse University, Syracuse, NY 13244-1240, USA. Application accepted until March 15, 1998, or until the position is filled. The targeted starting date is August 23, 1998. See: http://uplink.syr.edu/Faculty/Search/ for additional information.

Syracuse University is an Affirmative Action/ Equal Opportunity Employer. Qualified individuals

from underrepresented groups are urged to apply.

University of Alabama at Birmingham(UAB)
Department of Computer and Information Sciences

UAB Department of Computer and Information Sciences invites applications for a non-tenure track nine month Lectureship position. This is an undergraduate teaching position with teaching responsibilities in the lower division computer science courses for the major and service courses in computer literacy for non-majors. Applicants should have teaching experience in the field. An MS degree in computer science is preferred. Experience with object oriented technology and C++ programming is required.

UAB is a Carnegie Institute Division I research university located in Alabama's largest city of a population of almost a million. Current enrollment exceeds 16,000 students. The Department administers BS, MS and Ph.D. programs. Prospective candidates should send a resume with the names of three references to: Dr. Warren T. Jones (jones@cis.uab.edu), Department of Computer and Information Sciences CH114, University of Alabama at Birmingham, Birmingham, AL 35294-1170, UAB is an Equal Opportunity/ Affirmative Action Employer.

University of California, Irvine
Department of Information and Computer Science
Temporary Lecturer Positions

The ICS Department has occasional need for Lecturers to teach in the following areas: artificial intelligence, computer systems, implementation and analysis of algorithms, information systems, networks and distributed systems, and software systems.

Qualifications include a Ph.D. in Computer Science or an MS in Computer Science and substantial teaching experience. Salaries are commensurate with experience.

Applicants should forward a resume, the names and addresses of references, and teaching evaluations to:
Joy Schuler
Dept. of Information & Computer Science
University of California, Irvine
Irvine, CA 92697-3425
The University of California is an Equal Opportunity Employer, committed to excellence through diversity.

University of California, Irvine
Department of Information and Computer Science
Temporary Postdoctoral Research or Specialist Series Positions

The ICS Department has occasional need for high-quality postdoctoral researcher associates or specialists. Candidates should have an interest in theoretical, computational and experimental research.

Applicants should forward a resume, the names and addresses of references, and a brief explanation of career plans to:
Joy Schuler
Dept. of Information & Computer Science
University of California, Irvine
Irvine, CA 92697-3425
The University of California is an Equal Opportunity Employer, committed to excellence through diversity.

University of Illinois at Urbana-Champaign
Department of Computer Science

The Department of Computer Science at the University of Illinois Urbana-Champaign anticipates one or more full-time tenured and/or tenure-track appointments. Applicants are sought in all areas, with special emphasis on experimental systems, graphics, and multimedia systems. The department is a leading partner of the new NSF National Computational Science Alliance (NCSA) and is one of the leaders in the DOE Accelerated Strategic Computing Initiative (ASCI) Center for Simulation of Advanced Rockets. In addition, the department is launching a new distance learning effort to distribute a professional MS degree via the Internet.

Successful faculty candidates will be expected to initiate and conduct independent research and to perform academic duties associated with our BS, MS, and Ph.D. programs. Qualifications include a Ph.D. in computer science or a closely related field

(or imminent completion of degree), outstanding academic credentials, and an ability to teach effectively at both the graduate and undergraduate levels. To be considered for a tenured position, applicants must have recognized national and international stature. The salary is open, based on qualifications with a starting date of August 21, 1998. To apply send a resume, including the names of three references to:
Daniel A. Reed, Head
Department of Computer Science
1304 W. Springfield Avenue
Urbana, IL 61801
The UIUC is an AA-EOE. Minorities, women, and other designated class members are encouraged to apply.

University of Western Ontario
Department of Computer Science

The Department of Computer Science and the Faculty of Communications and Open Learning of The University of Western Ontario invites applications for a tenure-track position at the rank of Assistant Professor. This position is a joint appointment between the two units. Candidates should have a Ph.D. in Computer Science, Information Science, or a related discipline, and show evidence of strong research potential and excellence in teaching.

The successful candidate will bring enthusiasm, academic strength and the ability to work collaboratively to help build the new Faculty of Communications and Open Learning, one which takes as its scholarly domain the role and impact of information, media, and communications in the lives of individuals and in society. At the same time, the successful candidate will strengthen the area of multimedia systems or human-computer interaction within the Department of Computer Science. Teaching duties will include the development and delivery of courses in multimedia, human-computer interaction, or intelligent information systems both for the computer science program and for the new multidisciplinary program in Media, Information and Technoculture in the Faculty of Communications and Open Learning. Since some classes will include students with varying levels of computer science expertise, the ideal candidate will have the ability to relate to students who may or may not have a technical background.

The University of Western Ontario is located in London, a major Canadian city of 320,000, offering some of the best features of both small and large cities. Parks, tree-lined streets and bicycle trails coexist with an international airport and efficient public transportation. With a full-time enrollment of about 25,000, the University of Western Ontario graduates students from a broad range of academic and professional programs.

The Computer Science Department currently comprises 19 regular faculty plus additional visiting faculty members. The department offers B.Sc., M.Sc. and Ph.D. degrees in Computer Science, as well as an M.Sc. with specialization in Software Engineering. The department receives funding from government agencies and corporations for research into a broad range of areas, including artificial intelligence, computer algebra, computer graphics, databases, design of algorithms, formal languages and automata, image processing and computer vision, parallel and distributed computing, programming languages, reasoning with partial information and software engineering.

The Faculty of Communications and Open Learning (FCOL) comprises 24 regular faculty members and offers BA, MA (Journalism), Master of Library and Information Science, and Ph.D. The Ph.D. programs include specializations in

Professional Opportunities

Information Systems, Information Needs and Uses and Information Policy. Work in information systems in the faculty includes text retrieval systems, database management systems, expert systems and hypertext systems, including the network and telecommunications environments. Faculty within FCOL typically receive funding from either the NSERC (Science) or SSHRC (Social Science and Humanities) depending upon which domain their research methodologies reflect. Grants from non-governmental sources are also common.

The deadline for applications is April 3, 1998. With your Curriculum Vitae, please include a statement of your teaching philosophy and three representative publications. The effective date of appointment is July 1, 1998. Applications should be sent to:

Prof. S.M. Watt, Chair
Department of Computer Science, MC355
The University of Western Ontario
London, Ontario CANADA N6A 5B7
Positions are subject to budget approval. The

University of Western Ontario is committed to employment equity, welcomes diversity in the workplace and encourages applications from all qualified individuals, including women, members of visible minorities, aboriginal persons and persons with disabilities.

In accordance with Canadian Immigration requirements, priority will be given to Canadian Citizens and Permanent Residents of Canada.

University of Wisconsin, Madison
Computer Sciences Department
Faculty Position

Applications are invited for tenure-track assistant professor positions beginning August 1998. Applicants should have a Ph.D. in Computer Science or in a closely related field with demonstrated strength in scholarly research. Outstanding candidates in all areas of theoretical and applied computing are invited to apply. Of particular interest are applicants whose research interests lie in the areas of operating systems, networks, parallel and distributed systems, software engineering, theoretical computer science, computational

biology, computer graphics, or artificial intelligence. The successful candidate will teach at the Undergraduate and Graduate level.

The Computer Sciences Department at the University of Wisconsin-Madison has active research projects in a wide variety of areas, including artificial intelligence, computer architecture and VLSI, database systems, mathematical programming, modeling and analysis of computer systems, networking and distributed systems, numerical analysis, operating systems, parallel processing, program development environments, programming languages and compilers, and the theory of computing.

The department has received four NSF Institutional Infrastructure (Coordinated Experimental Research) grants. Previous projects investigated loosely- and tightly-coupled parallel computing. Our current project, "Midship," focuses on clusters of shared-memory multiprocessors.

The Computer Sciences Department has a large variety of sophisticated computer hardware to support research. This includes several hundred workstations, maintained by a central facility, the Computer Systems Laboratory. A locally developed

software package called Condor provides additional computing power for compute-bound tasks such as simulations. Condor automatically locates workstations that are idle and transfers jobs to them. Other equipment includes seven Sun UltraEnterprise symmetric multiprocessors (four 16-processor E6000s, one 12-processor E5000, one 12-processor E4000, and two 8-processor E5000s), a Cluster of 40 dual-processor Sun Workstations (COW), a 16-node IBM SP-2, and a 64-node Thinking Machines CM-5.

Further information about the department may be found at http://www.cs.wisc.edu/.

Applicants should submit a curriculum vitae and the names of at least three references to: Chair, Faculty Recruiting Committee, Computer Sciences Department, University of Wisconsin-Madison, 1210 West Dayton St., Madison, WI 53706. Deadline date for applications: April 15, 1998.

The University is an Equal Opportunity/ Affirmative Action employer and encourages women and minorities to apply. Unless confidentiality is requested in writing, information regarding the applicants must be released on request. Finalists cannot be guaranteed confidentiality.

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the creation of high-fidelity models. As described above, increasing model resolution to include smaller scales in a problem may increase the number of parameters that must be determined to the point that the computations to do so are not feasible. Bifurcation theory provides a framework for direct determination of information about how system behavior changes qualitatively with parameter variations. Implementation of algorithms based on this theory is a step towards computing parameter ranges that produce desired behavior.

From my perspective as a dynamicist, limitations of computer simulation technology are evident. Similar shortcomings occur in many other areas of numerical computation. Let me cite an example that illustrates how even algorithms for classical problems need improvements. Roughly a decade ago mathematicians solved a problem that had been popularized by Marc Kac as "can you hear the shape of a drum?" The mathematical problem is to relate the spectrum of eigenvalues for the Laplace operator with Dirichlet boundary conditions to the geometry of a planar domain. Classical results give formulas for geometric quantities such as the area of the domain and the length of its boundary in terms of the spectrum. Gordon, Webb and Wolpert gave the first examples of non-congruent planar domains with precisely the same spectrum. Examples include polygonal domains with fewer than a dozen edges. Now the solution of the Laplace equation is one of the most intensely studied problems in numerical analysis. Yet when Toby Driscoll (then a graduate student in applied math) attempted to produce accurate solutions of the eigenfunctions for two such domains, he found that the standard programs for solving the Laplace equation were not up to the task. The concave corners of the domains cause problems for these algorithms. Toby produced new algorithms based on conformal mappings of the domains. Pictures of two of these eigenfunctions are displayed on the home page of the Cornell Center for Applied Mathematics (http://

cam.cornell.edu). The point here is that we can hardly take for granted our ability to perform accurate computations for similar, but more complex, industrial problems.

Ironically, as numerical analysis is applied to larger and more complex problems, non-numerical issues play a larger role. Mesh generation is an excellent example of this phenomenon. Solving current problems in structural mechanics or fluid dynamics with finite difference or finite element methods depends upon constructing high-quality meshes of surfaces and volumes. Geometric design and constructing these meshes are typically much more time-consuming than the simulations that are performed with them. Developing data structures that capture the mathematical properties of these complex objects while still supporting efficient computation is important. Another non-numerical issue that has come to be particularly important is the data flow within our computers and algorithms. Moving data within computers has become the limiting factor for the speed of computer arithmetic. Particularly in parallel computers and distributed computing environments, we have complex memory hierarchies whose characteristics determine the efficiency of algorithms. Enormous effort has gone into ordering the arithmetic computations of fundamental linear algebra algorithms so that arithmetic processors do not sit idle most of the time waiting for data to arrive.

The continuing importance of numerical computation as a research area and critical technology is evident. I maintain that these issues go even deeper scientifically. The quantitative predictions of most modern theories can only be derived from extensive computations. In the twenty-first century, I believe that computer models will become a dominant mode of expression of scientific theories. For this to happen, we must be intelligent practitioners of numerical computation. This is the driving force behind emerging academic programs in computational science. Computer science has not embraced these efforts as a welcome enlargement of the domain of computer science. The core of computer science has come

to be defined more narrowly, with the result that numerical analysis is a shrinking part of computer science. I believe that this will harm computer science in the long run. My attitude towards these issues is shaped by my career as a mathematician. Mathematics has made a tradition of casting off applied endeavors when their practitioners became impatient with the constraints imposed by formal mathematical rigor. The result has been a continuing gap between mathematics curricula and the use of mathematics outside mathematics departments. Mathematics and mathematics education are enormously enriched when strong connections to the rest of science and engineering are maintained. I think that this is true of computer science as well. Numerical computation is an essential component of those connections. We must enhance the role of numerical computation as part of the core of computer science to ensure the vitality of computer science as part of science and engineering.

What do we need to do differently to foster timely advances in numerical computation? The issues cut across mathematics, computer science, and other disciplines so thoroughly that extensive cooperation will be needed to achieve our goals. This is simply hard. Government and industry seem to be ahead of universities in this regard. However, most companies do not have the expertise and do not want the responsibility for developing their own software tools. The commercial interests of software vendors are problematic because the development of a better algorithmic infrastructure requires significant investments to update current products. Thus, there is a continuing need for "precompetitive" research in this area. The federal focus upon multidisciplinary research initiatives the past few years recognizes that we need incentives to work together, but I think that universities deserve mixed marks at best for the successful conduct of such projects. Peer evaluations and rewards remain the purview of departments that frequently take a narrow view of their discipline. Consequently, we make it difficult for individuals to make a sustained commitment to projects

that require them to work across disciplinary boundaries. We can change this by broadening the scope of departments, giving them overlapping spheres of interest, and creating mechanisms for them to work smoothly together. In particular, I think that many departments, including those in computer science and mathematics, need to take responsibility for computational science. They need faculty who are knowledgeable and interested in computational technologies. They need curricula that teach students to become skilled and thoughtful users of these technologies in a world that becomes increasingly dependent upon enormously complex computational systems.

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Sam Nunn Policy Forum

Former Senator Sam Nunn will host a Policy Forum – *Information Security: Risks, Opportunities, and the Bottom Line* – April 6, 1998, on the campus of the Georgia Institute of Technology.

This event will explore issues addressing imminent threats to information security, the need to establish policy agendas, and the expansion of funding for research and education. The forum is a follow-up to the Presidential Commission on Critical Infrastructure Protection report (see "Presidential Commission on Critical Infrastructure", *CRN*, January 1997).

Responding to this call to action, Georgia Tech, Emory University, the University of Georgia, and Nationsbank are sponsoring this year's conference as the second part of a continuing series of policy forums addressing important national issues.