# COMPUTING RESEARCH NEWS

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## NSF's research funding cut

**By Fred W. Weingarten**
*CRA Staff*

Although the National Science Foundation requested an overall 17% increase for research funding in fiscal 1993, Congress appropriated less than it had allotted NSF in fiscal 1992.

Instead of the $2.212 billion requested for research and related activities, NSF received $1.859 billion, down slightly from fiscal 1992's estimated total of $1.875 billion.

The Computer and Information Science and Engineering Directorate (CISE), which was to get the largest increase [March *CRN,* Page 6], most likely will suffer the largest cuts.

The Senate Appropriations Committee tried to maintain some commitment to the High-Performance Computing and Communications initiative by mandating an increase. That type of protection can cause problems, because NSF Director Walter Massey would have to make significant cuts in other research programs in order to free funds to increase HPCC.

The report accompanying the Senate appropriations bill, HR 5679, included a controversial attempt to revise NSF's mission and strategic plan. The committee said NSF should only support research that promises economic benefit. This sweeping directive was followed by detailed instructions for grants and program activities.

The committee directed NSF to "take a more active role in transferring the results of basic research into the marketplace." The committee also said it "believes the foundation will play a key role in making the nation's research infrastructure more accessible to those endeavoring to build America's technology base and improve US economic competitiveness." The report listed several steps NSF should take to achieve this goal.

Reps. George E. Brown Jr. (D-CA), chair of the House Committee on Science, Space and Technology, and Rick Boucher (D-VA), chair of that committee's Science Subcommittee, sharply criticized the language in the report in a letter to Rep. Bob Traxler (D- MI), chair of the House Appropriations Subcommittee on VA, HUD and Independent Agencies. They said the

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## Subcommittee reviewing federal science policy

**By Joan Bass**
*CRA Staff*

A Senate subcommittee is spending the next year reviewing federal science policy to determine if it should be changed. An initial hearing on the topic was held in late September, and a series of hearings are planned for 1993.

"Research policy designed 40 years ago may no longer be suitable for addressing the problems of today's world," Rep. George E. Brown Jr. (D-CA) said at a press briefing where he released the *Report of the Task Force on the Health of Research.* "Traditional disciplinary and agency boundaries, unsophisticated models of innovation and economic benefit, and ideological approaches to federal involvement in the research process must be reconsidered."

The report was drafted by the House Committee on Science, Space and Technology, which is chaired by Brown. Rep. Rick Boucher (D-VA), chair of the committee's Science Subcommittee, is overseeing the Task Force on the Health of Research.

The earliest that the task force would release any recommendations would be next October, but Boucher said it is more realistic to expect the recommendations in January 1994.

Boucher stressed that university-based researchers would not be left behind if science policy is reshaped. "We are not starting with the premise that basic research has served us badly," he said, adding that one of the outcomes of this re-evaluation of policy will not be a diminished role for universities.

However, the federal science agenda needs to be more closely linked to the commercial use of research findings; and science and technology funding must be used to help meet national goals and must benefit society, the report said.

Congress should strengthen priority

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### Inside CRN



## Controversy over NRC report resolved; NRC, petitioners issue joint statement

**By Joan Bass**
*CRA Staff*

Both sides involved in a controversy over a National Research Council report have resolved their differences and issued a joint statement regarding the report and a petition that called for withdrawal of the report.

The joint statement was signed by two of the petition's sponsors—Robert Boyer of the University of Texas and John McCarthy of Stanford University—and by William Wulf, chair of NRC's Computer Science and Telecommunications Board, and Juris Hartmanis, chair of the committee that wrote the report.

NRC released C*omputing the Future: A Broader Agenda for Computer Science and Engineering* in July at CRA's Snowbird Conference '92 [September *CRN,* Page 1]. Shortly after that, a petition calling for the withdrawal of the report so it could be rewritten was sponsored by John Backus, Boyer, Barbara Grosz, Donald Knuth, McCarthy, Jack Minker, Marvin Minsky and Nils Nilsson and was circulated via E-mail. By early October, more than 900 people in the computer science and engineering field had signed the petition.

A statement from the sponsors of the petition, which was included with the petition when it was sent over E-mail, said that although much of the report was useful, the sponsors "consider it misleading, and even harmful, as an agenda for future research."

All of the documents associated with the petition are in the directory "pub/jmc at sail.standford.edu" and are available by anonymous FTP. A moderated bulletin board set up to conduct the debate can be accessed at CTF-DISCUSS@CIS.UPENN.EDU. Send administrative requests, such as adding a name, to CTF-DISCUSS-REQUEST@CIS.UPENN.EDU. At press time, a Usenet newsgroup with the name "comp.org.cstb.discuss" was being created.

In mid-September, the Committee to Assess the Scope and Direction of Computer Science and Technology and Frank Press, the president of the National Academy of Sciences, each issued a response to the petition. The petitioners then issued a response to those two statements.

In late September, McCarthy met with Press and members of the CSTB. In response to petitioner's concerns, Hartmanis and McCarthy will "develop a statement on the nature of computer science, its subdisciplines and specific opportunities for basic research," the joint statement from McCarthy, Boyer, Hartmanis and Wulf said. "These are different matters than were intended to be included in *Computing the Future.*"

CSTB did agree to make some clarifications in the report when it is reprinted, to avoid "further confusion and misunderstanding," the statement said. "The principle change would be to make clear that the misunderstood table in the executive summary simply constitutes a limited illustration of potential linkages between some computer science subdisciplines and selected application arenas."

The petition's sponsors jointly made their point about the issues raised in the petition, the statement said, and CSTB officials will talk individually with anyone who has other problems or comments related to the report.

Attendees of the September meeting agreed there are communications problems between NRC and the computer science and engineering community that need to be identified and considered.

Not everyone in the CS&E community fully understands how the research environment is changing, the statement said.

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## Opinions



***CRN welcomes letters from its readers. Letters may be edited for space and clarity. Send them to Joan Bass, Managing Editor, CRN, 1875 Connecticut Ave. NW, Suite 718, Washington, DC 20009. E-mail: jbass@cs.umd.edu. Letters must include your name, address and telephone number or E-mail address.***

# Who will build our new systems?

**BY Philip M. Lewis**

*This editorial is adapted from an article titled, "Information Systems is an Engineering Discipline," which appeared in* Communications of the ACM, *vol. 32, no. 9, September 1989, pp 1045-1047.*

The industrialized world is significantly enhancing its information system infrastructure. New information systems are being designed and built in such diverse areas as air traffic control, hospital patient monitoring, military command and control, stock transactions, manufacturing and engineering. During the next decade and beyond, the lives and safety of our citizens, as well as the competitiveness of our country, will depend on the correct functioning and efficiency of these new systems.

Who is going to be responsible for building these new systems that are so important to our national economy? To make the issue specific, suppose you were responsible for developing one of these systems. Your boss reminds you that the proposed system will operate in an environment in which human lives and property are at stake. He also reminds you of the many failures of such development projects—systems that are late, grossly over budget, or incorrectly designed. Your career is on the line. Who would you select to be the manager of the system development project?

A traditional computer scientist? Not likely. The computer science community has, by and large, ignored the entire area of information systems. Most computer scientists view people who implement information systems as rather low-tech Cobol programmers who were not smart enough to get a computer science degree. Many academic computer science departments actively brainwash their undergraduates into believing that it is below their professional dignity to work in information systems. If you could find a computer scientist willing to do the job, you might find someone who has the technical skills to design and implement the internals of the system—the database, algorithms and communications—but is weak in the engineering skills required to plan, organize and manage the project.

Would you pick an electrical engineer? Quite likely, if the application is in military or engineering systems. You might find that the engineer has technical knowledge in the application area (for example, radar systems); the ability to design and build to specifications; and, if the person is a senior engineer, the skills to plan, organize and manage the project. However, you also might find that the engineer is weak in the computer science skills needed to design and implement the system internals. Thus, the project might be completed on time and budget, but might not use up-to-date computer science technology (a situation that often occurs in military systems).

Would you pick an information systems professional? Quite likely, if the application is in business or management systems. Unfortunately, you might find that the information systems professional—particularly one educated in existing academic information systems programs—is weak in both technical and engineering skills.

Who then would you select to manage your information systems development project? In the broader context, which technical discipline will take the lead in designing and building the information systems our country needs to support its information infrastructure?

One source of confusion is the name "information systems" itself. The academic and industrial information systems community commonly uses the term in a rather narrow sense to refer only to management or business information systems. Yet the technology underlying information systems has applications in many other fields. A military command and control system is not unlike a factory management system, and an air traffic control system is the ultimate material tracking system. In the past, there have been significant differences in scale. Business information systems often were relatively small (systems that could be built by a person who had taken only one Cobol course), while military and related systems were significantly larger, sometimes requiring millions of lines of code.

That scale difference, however, is disappearing. Many modern business information systems are quite large and rival their military counterparts in complexity. We have to broaden our perspective as to what constitutes an information system and the technical challenges involved in the implementation of such a system.

I believe we should view information systems as an application area of computer science. The technologies underlying information systems come largely from computer science. The design of most information systems uses database, communication and user-interface technologies, which are at the core of computer science. The skills and techniques required to specify, design, code, validate and manage large information systems projects come from software engineering—also a part of computer science. Indeed, information systems can be viewed as the application of computer science to large systems.

Each year, more than 30,000 students graduate with a bachelor's degree in computer science. Many of those students get jobs building software. About the only "application areas" for computer science we cover in our undergraduate curriculum are compilers and operating systems. But there are not enough compilers and

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report's language was "unprecedented and inappropriate" and that the "degree of micromanagement…is counterproductive to the efficient management of NSF." Brown and Boucher demanded that the language be removed from the conference report, but they did concede that there should be a legitimate debate over whether NSF's mission should be expanded.

The conference committee report was non-committal on the Senate language, although it did remove some of the specific spending floors that had been imposed, giving the NSF director greater flexibility in accommodating the budget cuts. Passage of the conference bill was accompanied by a discussion on the House floor between Brown and Traxler. During this dialogue, which established a clearer record of congressional intent, Brown obtained assurances that the report language did not alter in any way NSF's existing statutory role. He also was assured that the grants specifically mandated in the bill would be subject to standard NSF peer review. (Brown is particularly adamant that NSF's research budget does not become a pork-barrel attraction.)

This was not the first time during this session that Senate appropriations has taken aim at NSF and its priorities. Earlier this year, in what was interpreted as a political counterattack to the president's attack on congressional pork barrel, several NSF grants were identified by name as "administration pork," and $2 million was rescinded from NSF's fiscal 1992 appropriation. In conference, the specific grants—all for social and biological science—were removed from the bill, although the $2 million cut remained and the report language suggested the grants as possible cuts. The report language in the recision bill also said NSF should direct its research support toward economically useful topics.

Other agencies are experiencing money problems. The Defense Advanced Research Projects Agency's (DARPA) high-performance computing program has been attacked twice. The House Armed Services Committee tried to remove $45 million of DARPA's high-performance money intended for computer systems research [September *CRN,* Page 10]. Recently, $68.6 million of Defense's HPCC money was removed from that account and added to a special $2 billion defense conversion account directed toward community transition assistance and development of dual-use technology. The money will be controlled by the Defense Conversion Commission.

Although HPCC might seem to qualify for money from that account, it would be directly competing for funds with politically popular programs such as job training and community development. To date, attempts to remove HPCC from this program have failed, and the issue remains unresolved.

At NASA and the Energy Department, science budgets also are being squeezed. Both agencies are dealing with external budget constraints, but also face budget problems from internal

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## Expanding the Pipeline

# Interdisciplinary degree has its advantages

BY **Thelma Estrin**

An interdisciplinary master's degree in computer science (CS) would provide CS academics with an opportunity to support interdisciplinary research in the university. Although the National Science Foundation has sponsored interdisciplinary research for the last decade, the strategies of universities are based on single disciplines, and most departments do not encourage young faculty to pursue interdisciplinary work if they are interested in obtaining tenure. This in turn discourages students from pursuing advanced degrees in cross-disciplinary subjects, especially if they wish to pursue academic careers. (Interdisciplinary, cross-disciplinary and multidisciplinary are equivalent in this discussion.)

I am advocating such a program in this column because the large number of women obtaining undergraduate degrees in the natural sciences would provide a large base for increasing the number of women in graduate CS programs.

Physicists, chemists, mathematicians, astronomers, biologists, psychologists and computer scientists frequently collaborate on complex projects involving such fields as neuroscience, environmental hazards, genetic and medical engineering, cosmology and artificial life. Scientific computation has become a basic tool for R&D, and many researchers have learned computer science skills as an additional field of expertise so they can solve their scientific or technological problems more economically or quickly. Scientific computation advances are pushed by the contributions of computer experts as research partners, and pulled by encouragement to improve US competitiveness for high-technology sales in global markets.

The availability of a master's program in interdisciplinary research could attract many more science and engineering students to CS disciplines. NSF reported that, in 1990, women received 72% of the undergraduate degrees in psychology, 48% of the degrees in biology and 15% of the degrees in computer science. Computer science is younger than other scientific fields and should be expected to have more women and minorities, based on both the breadth of application areas and the typically less hostile work environments.

The attitudes toward women "moving up the ladder" are not as extreme as in the more traditional physical sciences of physics, mathematics and chemistry where "old boy" networks still are strong. In the biological sciences, advances in biomedical research based on computer technology, plus the large number of women with biology majors, should make computer science an attractive discipline for female graduates.

Challenging research on complex systems is based on the synthesis of methodologies, databases and experience in several disciplines. Yet the departmental structure of universities hinders the rapid advancement of interdisciplinary fields. Large-scale interdisciplinary research creates problems on the campus, based on "turf issues" ingrained in each department's competitive need for funding and intellectual esteem. The promotion of young faculty to tenure and then to more advanced positions, often is controlled by academics who cannot achieve consensus on judging multidisciplinary work.

Academics do not have a clear paradigm for dealing with interdisciplinary-based promotions and often cannot agree on what constitutes a contribution. This research cannot always be judged by one scientist's work; results frequently are a team effort. Interdisciplinary results often are published with several authors and in non-traditional journals, or in refereed conferences, which typically are viewed as disincentives by traditional faculty. Some professors believe that people involved in interdisciplinary work are trying to succeed without abiding by more rigorous standards of quality in the existing disciplines. Some critics believe diversity is eroding the quality of university research. Such research is vital to the economy and should be encouraged. The need for greater global competitiveness and technological integration requires synthesizing and integrating the skills of various disciplines.

> ***Some professors believe that people involved in interdisciplinary work are trying to succeed without abiding by more rigorous standards of quality in the existing disciplines***

CS professors should create an academic pipeline for interested science and engineering undergraduates and help them pursue an interdisciplinary CS master's program. The master's thesis can contribute to the candidate's training and to the field. The master's program should begin with a rigorous summer course in CS fundamentals, to place students without a CS undergraduate degree on more of an equal footing. Program supervision should include sympathetic instructors who develop a friendly and supportive group atmosphere. Instructors should encourage students to ask questions.

An informal overview of the field of information technology, including discussions of ethics, societal values and future trends, should accompany this course. Following such an intensive summer course, the program should include typical courses offered to traditional CS master's students, plus an interdisciplinary thesis in the discipline the student had committed to as an undergraduate. The thesis should be performed in a campus interdisciplinary center or in an industrial setting.

This program would add a strong emphasis in application areas to CS graduate seminars throughout the academic year. Graduates of this master's program would have a choice to proceed toward a doctorate or move to industry or government positions. Such a program would attract women.

Behavioral studies in the past 20 years have shown that women prefer integration rather than separation, prefer collaboration over competition, and prefer dealing with a complete problem rather than focusing on narrow aspects. Cooperativeness is one of women's hidden sources of power. It sometimes is called "cooperative individualism," a form of association that does not pit individuals against each other, but merges the individual self-interest with that of the group.

A master's degree in computer science can offer a female student working on a complex technological problem the opportunity to thrive on the "cooperative individualism" of an interdisciplinary research team. With a larger female enrollment in an interdisciplinary master's program, the proportion of women interested in earning a doctorate in computer science should increase.

*Thelma Estrin is a Professor Emerita at the University of California, Los Angeles. From 1960-1980 she organized and then directed the Data Processing Laboratory of the UCLA Brain Research Institute. She is a Fellow of the IEEE and AAAS.*

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operating systems being built in the world to employ 30,000 more computer scientists each year. Hence, an increasing number of our graduates are getting jobs building information systems (particularly if we use our broader definition). We need to recognize that in our curriculum and in the culture of our field.

Traditional information systems programs in business schools have emphasized the importance of knowledge of the application area—in their case, business and management. Such application knowledge is important; we all know examples of systems that do not meet the real needs of their users. Part of the culture of our field should be that computer scientists work in various application areas and that every student should get application knowledge in one or more such areas. For example, a minor in business would be important for someone interested in business-oriented systems, and electrical engineering courses would help someone interested in systems that interact with hardware.

We are being encouraged to broaden the agenda in computer science. In the case of information systems, I would state the situation somewhat differently: Information systems is a part of computer science; we need to enlarge our view of computer science so that it corresponds with that reality.

*Philip M. Lewis is chair of the computer science department at the State University of New York at Stony Brook.*

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demands, including rapidly growing "big science" projects—the supercollider and the space station.

The inadequate funding for research in the fiscal 1993 budget is bad news. And unless there is a significant change in priorities and budget constraints, the fiscal 1994 budget will not look much better.

## Policy News

# Commission on the Future of NSF is established

At the request of NSF Director Walter Massey, the National Science Board (NSB) has established a Special Commission on the Future of the National Science Foundation. Massey said that because the political and economic environment for science and engineering research is changing, NSF's mission and programs must be re-examined. NSB is NSF's policy-making organization.

The commission is co-chaired by William Danforth, chancellor of the Washington University in St. Louis, and Robert Galvin, chair of the Executive Committee of Motorola and former chief executive officer of that company. The commission is planning three meetings to examine the national research climate, models of research excellence, and NSF and its role in funding research. The commission also may form subcommittees or hold other meetings.

### Members of the special commission

Jacqueline Barton
*California Institute of Technology*

Lindy Boggs
*Former US Representative from Louisiana*

Lewis Branscomb
*Harvard University*

Peter Eisenberger
*Princeton University*

Marye Anne Fox
*University of Texas at Austin*

C. Peter Magrath
*National Association of State Universities and Land-Grant Colleges*

Ruben Mettler
*Retired from TRW Inc.*

Percy Pierre
*Michigan State University*

Frank Rhodes
*Cornell University*

Earl Richardson
*Morgan State University*

Ian Ross
*AT&T Bell Laboratories*

William Rutter
*Chiron Corp.*

Donna Shalala
*University of Wisconsin at Madison*

The process is designed to be open to comments from the community. "The commission's report, due in late November, will incorporate the views of scientists, industry leaders, university administrators and educators," said NSB Chair James J. Duderstadt. "Once the commission's recommendations are received, the board will continue to seek extensive and constructive participation from the scientific community in determining future directions of NSF."

The commission has invited written comments on two issues:

• NSF support plays an important role in the health of the nation's academic system, which is the source of new ideas and human resources in science and engineering. How can NSF maintain and enhance this vital national resource?

• In light of the many changes in both science and world affairs, should NSF build on its traditional mission by pursuing a broader array of research and education objectives and doing more to link academia and industry? If it should, what strategies could the agency adopt?

CRA's board of directors will respond to these questions and submit comments on the commission's broader agenda.

# NSB study: Strengthening industrial investment is key

Strengthening US industrial competitiveness may become an important responsibility of the National Science Foundation, said a report prepared by that agency.

The report, *The Competitive Strength of US Industrial Science and Technology: Strategic Issues,* was written by NSF's National Science Board Committee on Industrial Support for R&D.

Some observers have said the report may be used in the ongoing debate over NSF's future mission and role. In the report, NSB said industrial R&D and competitiveness is important and that NSF may play a significant role in improving these areas.

The report highlighted some alarming trends in overall industrial R&D investments and included four major findings:

• "The real rate of growth in US industrial R&D spending has declined since the late 1970s and early 1980s." The report also said that "since 1985, US growth in both total and non-defense R&D expenditures has been less than that of many of its major industrial competitors."

• "The allocation of US R&D expenditures is not optimal." The report said "the balance between defense and non-defense expenditures is disadvantageous compared to that of foreign competitors."

• "US expenditures are not as effective as they should be in producing needed results." This country's once strong competitive position has been deteriorating during the last 10 years.

• "The current information base on industrial science and technology is inadequate: It has gaps, is questionable in parts and does not provide enough detail to meet the needs of policymakers."

The report showed significant variations between industrial sectors, which means more sector-specific analyses may need to be done. The computer industry experienced steady growth in R&D expenditures and now leads all other industries in company-funded R&D as a percent of sales (more than 8% in 1990, compared to an overall rate of slightly more than 3%), the report said.

The report recommended several actions for government, industry and NSF. Several of the recommendations, if adopted, would move NSF further along toward making the improvement of industrial competitiveness a major mission of the agency. Recommendations for starting and expanding programs did not include cost estimates or indications of whether the funds should be added to NSF's budget or reallocated from other NSF programs.

The report is available from Forms and Publications, National Science Foundation, Washington, DC 20550; tel. 202-357-7861. Document # NSB-92-138.

**Attention CRA Members:**

CRA has assembled a package of federal policy information. The package includes the *Report of the Task Force on the Health of Research* [See Page 1 of this *CRN*], the NSB report, *The Competitive Strength of US Industrial Science and Technology: Strategic Issues*, documents from NSF and the statement CRA submitted to the Special Commission on the Future of NSF.

The package is available to CRA members only. The designated organization representative can contact Phil Louis at tel. 202-234-2111 or E-mail: plouis@cs.umd.edu.

# New HPCC coordinator named

The White House has selected Donald A.B. Lindberg to head the new National Coordination Office for High-Performance Computing and Communications. Lindberg is director of the National Library of Medicine.

Under Lindberg, the National Library of Medicine has become a leader in developing very large on-line text retrieval systems. The National Institutes of Health has been an active participant in HPCC since the program's inception.

The administration selected Lindberg for several reasons. He is a well-known and respected scientist and administrator who has credibility within Congress and the administration. Because he is not associated with one of the "Big Four" agencies that started the program (the National Science Foundation, Defense Advanced Research Projects Agency, Energy Department and NASA), he is less likely to be viewed as biased on some of the more contentious interagency squabbles, particular those over the National Research and Education Network.

Lindberg also has the perspective of an experienced user of high-performance computers, which strengthens HPCC's grand-challenge rationale.

Lindberg told CRA that a major role for his office is to serve as a liaison and contact point for the communities concerned with HPCC. He said he is seeking public input on HPCC programs.

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setting for S&T funding and use legislative mandates and other measures to perform evaluations of federally funded research programs and to link performance to funding, Brown said.

Current science policy assumes a "linear relationship between basic research and societal benefits," Brown said. "We don't really know if the structure of the federal research system is ideally suited to address national objectives." During the 18 months the Science Subcommittee studied the US research system, senators saw much evidence of stress on the system.

The US high-technology market is not as competitive globally as it once was, and mission-oriented research programs at many federal agencies are not producing results relevant to society or meeting statutory goals, the report said.

An increasing number of researchers and research universities are competing for a limited pool of funding. Funded research projects often must be "carried out in aging laboratories, which due to severe federal fiscal constraints, are not being modernized at an acceptable rate," Boucher said. The national laboratories, once geared toward defense-related research, now are struggling to redefine their missions. And industrial sponsors are decreasing the amount they spend on R&D.

Other stresses on the research system include the neglect of undergraduate science education and the changing public attitudes about the scientific establishment because of widely reported instances of scientific misconduct.

The task force made two general recommendations to help link the research agenda and societal needs:

• The Federal Coordinating Council on Science, Engineering and Technology should be used to improve the ability to develop programs that respond to the national needs.

• Performance assessments should be part of the research process, and programs should be evaluated on the progress they make toward achieving specific societal goals.

If Congress could measure performance better without constraining the freedom of the research community, Brown said, "We may help

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# Policy News

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Press said the basis for public support of science is being challenged. A senior congressional staffer said science funding will not increase in the next fiscal year, and may not increase the year after. "The need to nurture basic research in all disciplines, in spite of these trends, is an issue for the whole community," the statement said.

NRC's mission also is not clear to everyone in the computer science and computer engineering communities. Some of the petitioners seemed to think NRC is a government agency. However, NRC is an independent, non-profit organization that is the operational arm of the National Academies. The council "advises government and often delivers advice that the government would prefer not to hear," the statement said.

At a public session following the meeting between McCarthy, Press and CSTB members, Michael Nelson, a Senate Commerce, Science and Transportation Committee staff member said Congress finds NRC reports useful because independent senior members of the scientific community generate the reports.

The changing environment for science means the science community needs to act collectively, and members of the various disciplines need to exchange information and ideas with each other. "Toward this end, an intellectually substantive, non-polemical debate over the issues raised in *Computing the Future* and in the petition for its withdrawal will benefit the field," the signers of the joint statement said.

NRC officials said they would not comment on the petition, beyond what was written in the joint statement. McCarthy said the joint statement addressed the issues raised in the petition, but that he had other problems with the report that may not reflect the views of the other petitioners.

Merging the two disciplines of computer science and computer engineering into a single discipline called CS&E is not a good idea, McCarthy said. Scientists make discoveries about phenomena and engineers make useful artifacts. "While science and engineering are closer together in computer science than in other fields, the distinction is important," he said.

Identifying basic research with theory, and program development with applications is a mistake, McCarthy said. "Artificial intelligence, for example, has a large component of experimental research, where experimental programs are written for what they will teach us," rather than for how directly useful they will be, he said.

Linking computer science and engineering with large, short-term projects, such as the High-Performance and Communications (HPCC) initiative, also is a mistake, McCarthy said. "When HPCC ends, the long-term research in science or engineering supported under its umbrella goes into limbo," he said, adding that if the initiative fails, basic research supported by the project "is in additional bureaucratic trouble."

McCarthy said he is not opposed to encouraging computer scientists to learn about computational problems outside of their disciplines. However, some of the methods proposed in the report to broaden computer science "seem rather heavy handed, though not quite so drastic as the Chinese Cultural Revolution practice of sending the scientists to the fields to learn from the peasants," he said.

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to bolster the integrity of this community by discouraging it from making overzealous promises to gullible and impressionable Congress people."

Boucher said his subcommittee will be talking with national science policy experts, university-based researchers, users of research and other interested parties. He said he is setting up an external advisory group composed of high-ranking members from industry and academia, and science and technology policy experts.

The report also calls for "more judicious oversight of the White House Office of Science and Technology Policy [OSTP]." The goal of the oversight over OSTP "is to help move science policy-making from the current, ad hoc, agency-by-agency, OMB-dominated process that exists today, to a more strategic process oriented toward the conduct, goals and users of research," the report said.

## CRA board of directors to hold December meeting in Chicago

The CRA board of directors will hold its next meeting Dec. 10–11 in Chicago at the O'Hare Hilton, which is located in the airport complex. The board meeting tentatively will be from 2PM–10PM on Dec. 10 and from 9AM– 2PM on Dec. 11.

Observers will be charged the cost of a dinner and a lunch if they plan to eat with the board. If you are interested in attending, please contact Kimberly Peaks of CRA at tel. 202-234-2111 or E-mail: kimberly@cs.umd.edu as soon as possible, but no later than Dec. 7.

## International News

# Western scientists know little about Japanese CS

BY David Notkin and Richard D. Schlichting

*The following is a summary of an article titled, "Computer Science in Japanese Universities," which has been accepted by* IEEE Computer. *The article is scheduled to run in May.*

Despite the association of Japan with high technology, most Western scientists know little about computer science in Japan. Many factors contribute to this phenomenon, including language and cultural differences, a shortage of readily available information and a degree of technical chauvinism. Our goal is to provide an informal portrait of computer science in Japanese universities in the hope that this will lead to enhanced awareness and increased interaction.

Our observations are based on sabbaticals we took in Japan. In 1990–91, David Notkin spent three months at the Tokyo Institute of Technology and nine months at Osaka University. Richard Schlichting spent seven months at the Tokyo Institute of Technology in 1989–90; he recently spent two more months there. We each visited several dozen Japanese universities and companies.

### Japanese universities

The major public universities in Japan are sponsored by the government. Among these, the top tier are considered to be the University of Tokyo, Kyoto University, Osaka University, Nagoya University, Kyushu University, Hokkaido University and Tohoku University. In the engineering disciplines, the Tokyo Institute of Technology often is added to this top tier. Of the many private universities, perhaps the two best known are Keio University and Waseda University. Computer science is well-represented at all of these schools.

The Japanese university system is distinguished in part by the strong central control exercised by the Ministry of Education (*Monbusho*). *Monbusho* provides the primary funding for both teaching and research at national universities, and regulates staffing levels, pay rates, degree programs, numbers of students and building construction and maintenance. *Monbusho* also has significant control over private universities, despite its lack of formal government affiliation.

Several new programs related to computer science recently have been initiated despite *Monbusho's* generally conservative bent. One is Keio University's environmental information engineering program. Two others are the newly created Japan Advanced Institutes for Science and Technology (JAIST), funded by *Monbusho,* with support from industry and local governments. These institutes are oriented exclusively toward graduate education and research, which is a significant and potentially risky departure from the current educational structure in Japan.

The primary faculty ranks are *joshu, koshi, jokyoju* and *kyoju.* All positions are tenured on appointment. The *joshu* position is akin to a postdoctoral or research associate position in the United States. *Koshi, jokyoju* and *kyoju* usually are translated as assistant, associate and full professor, respectively, although the equivalencies to the American ranks are not exact. Progression through the ranks depends on the availability of openings, as well as on seniority and age.

Each department in Japan is divided into relatively autonomous laboratories (*koza).* Each laboratory is headed by a full professor who acts as the administrative head of the unit, performing many of the same functions as a department head in the US system, as well as the leader who sets the tone and style of the laboratory. He—and they are virtually all male—serves as a mentor to the junior faculty, graduate students and advanced undergraduate students in the laboratory.

This role even extends to the point of being responsible for finding positions for graduating students and sometimes even arranging marriages for students and staff. Consistent with Japanese culture, this control is exerted to turn the laboratory into a cohesive group in which individual achievements are downplayed and overall productivity is stressed.

Full professors have all but complete control over whom they hire. Professors select former students—whom often are in a more junior position in the laboratory—for openings whenever possible. When a full professorship opens, it is common for the associate professor to be promoted.

Other common candidates are former members of the laboratory or the department. These candidates may come from another university or from industry. (In contrast, moving from academia to industry is highly unusual in Japan.)

The koza system tends to narrow the focus of the laboratory's members. Research collaboration between members of different laboratories is rare at many universities, and even formal social activities tend to be associated with a single laboratory. The result is that there is somewhat less breadth of vision than there would be in a typical US department.

This problem is in part balanced because the Japanese seem less plagued by the "not invented here" syndrome: They are less likely to be aware of a key concept or technology. But when they learn about it, they are far more likely to take full advantage of it.

Women hold fewer than 10% of the computer science faculty positions. With few Japanese women matriculated in Ph.D. programs, no affirmative action programs and no societal or university pressures to change, this is unlikely to change in the near term.

There also are few foreign faculty. As of 1989, there were seven non-Japanese tenured faculty in all disciplines in all Japanese national universities [Geller90].

### Students

The Japanese student population is highly homogeneous. The population is overwhelmingly male, especially at the graduate level. There are relatively few foreign students; Western students are a rarity.

The Japanese government has recognized this as a problem and recently instituted a program intended to increase the number of foreign students. However, given the number of obstacles encountered by such students, it remains to be seen how successful the program will be.

The graduate student population is proportionally smaller in Japan: Only "eight out of every 10,000 citizens enroll in graduate school [in Japan], compared with 71 in the United States, 29 in France and 22 in Britain [Shi92]," an article in the *Japan Times* said. The same article reports that only 4.8% of the total student population are graduate students, compared with 15.6% in the United States.

One reason that students shy away from graduate school is there is no tradition of or mechanism for awarding financial aid. Another reason is that the Japanese labor shortage leads companies to go to incredible lengths to hire recent graduates. In addition, many Japanese companies have their own training programs to give employees the rough equivalent of a master's degree. Finally, the added salary that master's and Ph.D. recipients receive does not come close to compensating for the lost years of earning during graduate school.

> ***A high level of publication activity is not widely recognized outside of Japan, in part because few publications are in English***

### Research

There are many professional organizations and associations related to computer science in Japan. These range from general societies like the Information Processing Society of Japan (IPSJ) and the Institute of Electronics, Information and Communication Engineers (IEICE), to those with a more specialized mission like the Robotics Society of Japan (RSJ) and the Japanese Society for Artificial Intelligence (JSAI). These societies sponsor publications and regularly hold technical meetings.

There are more than two dozen regular journals and transactions produced by Japanese computer science professional societies and associations [Jacoby91]. This high level of publication activity is not widely recognized outside of Japan, in part because few publications are in English. The availability of these journals in other countries is limited. As one example, in 1989 the *Journal of Information Processing,* an English-language IPSJ publication, was carried by only about 25 US libraries. Only the library of the Patent and Trademark Office receives the Japanese-language *Transactions of the IEICE (D-1).*

Many Japanese choose to publish in their own outlets instead of internationally. One reason is that language is less of a hurdle. With promotions and salary based almost entirely on seniority, there is little in the reward structure to encourage them to choose international outlets. A consequence is that foreign researchers often lack the big picture about computer science in Japan because foreigners tend to see the small fraction of the results published in international conferences and journals.

General-purpose computing facilities devoted to research are similar to what one would find in many US universities. Sun Microsystems Inc. workstations and X terminals are widespread. A line of Unix workstations from Sony also are popular, in part because they include hardware support for written Japanese. The facilities, while generally adequate, still seem to be a notch below that of many top US departments. Many of the technical support functions that US university researchers take for granted are performed in Japan by professors or students, because of a lack of support staff. This leads to computing facilities that are more ad hoc than in most US departments.

Special-purpose equipment, such as parallel machines or high-end graphics engines, is scarcer in Japan than in the US. Perhaps the main reason is that individual laboratories generally do not have the resources to buy such equipment.

Network connectivity between sites in Japan, and between Japan and the United States, has improved greatly in the past decade. A high-speed link in Hawaii connects key Japanese networks with the Internet, providing excellent support for trans-Pacific networking.

*Monbusho* provides most of the research money to national universities. Base funding is low, supporting the basic functioning of each laboratory. One of *Monbusho's* grant programs is for directed research on specific, although widely drawn, topics. In computer science, these topics currently include decentralized and autonomous systems, parallel systems and concept development and knowledge acquisition. In 1990, across all disciplines, Monbusho's total research grant budget was 55.8 billion yen, roughly $400 million.

Another source of funds is the Ministry of International Trade and Industry (MITI), well-known outside of Japan as the sponsor of such large projects as the Fifth Generation Project and Sigma. Because the primary purpose of MITI's projects is to enhance the industrial sector, the little money that does flow toward universities is tied to a specific project and involves cooperating with industrial partners.

In 1990, direct financial support from companies totaled 42.6 billion yen (about $300 million). In 1989, the average contract was for less than 5 million yen (about $45,000), which is small relative to industrial grants in the United States. Companies often give small grants to the professor to ensure access to his graduating students. Companies also occasionally contract

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## International News

# Proposal for Canadian network includes a gigabit testbed

**By Douglas Powell**

Advocates of high-speed networking in Canada have received strong endorsements from a number of communities for changing a proposed T1 (1.5 mbits/sec) national backbone to a gigabit-per-second network.

On the provincial level, an Ontario telecommunications sector report, which has garnered serious government attention, advocates a high-speed network, starting with a fiber-optic testbed connecting Ottawa, Toronto and Waterloo. The moves come as industry leaders, politicians and researchers realize that the fiber future may be passing by Canada.

Less than a year ago, the Canadian Network for the Advancement of Research, Industry and Education (CANARIE) was proposed as a successor to the existing national backbone, CAnet. Under that proposal, the network would first operate at T1 speeds and move to T3 by 1995. But with strong industry backing from Stentor, an alliance of Canadian telephone companies and Unitel Communications Inc., the CANARIE proposal has been altered to incorporate a gigabit testbed along with the planned upgrades to CAnet.

The final CANARIE business plan, which was expected to be submitted in October, calls for an immediate upgrade of CAnet to T1 speeds and for the establishment of a laboratory by Stentor and Unitel, in partnership, to provide gigabit testbed facilities. Phase 2 would upgrade CAnet to T3, continue development of applications and services and have the carriers establish showcase and demonstration facilities. Phase 3 would represent the move to an operational gigabit network by the year 2000. Government officials warn that to date, money has only been allocated for the first phase. But nevertheless, they are optimistic.

"I expect announcements around the turn of the year," said Pat Sampson, director of technology applications with Industry, Science and Technology Canada. "We're currently in a watershed situation, where an awful lot of work has been done in the planning phases. It is all about to come to a head with a formal proposal about to come in, basically from industry. It is now very much led by industry."

Tess McLean is a senior consultant in the information technology practice of Toronto-based Ernst and Young and she has worked on the project for three years. She said the final business plan for CANARIE has become a "strong private sector document. We've created something that makes good business sense, something that people can recognize is good for networking in Canada."

At the same time, a special advisory committee to the Ontario Minister of Culture and Communications has recommended that Ontario go ahead and upgrade the regional net—Onet—as a way to jump start innovation in the telecommunications sector. The report, *Telecommunications—Enabling Ontario's Future,* recommends the Ontario government should:

• Accelerate the development in Ontario of specialized information networks, including an Ontario Research and Education Network, which is knit into a network of networks that are based on interoperability and widespread access;

• Define networks as research and education networks, libraries, environmental networks, community information networks and others;

• Strike a partnership with existing and planned network groups, the telecommunications carriers—including cable—and other directly involved interests, to develop an effective development plan by mid-1993; and

• Launch an investigation into the feasibility of establishing by this December a "virtual university" to provide specialized training and degree programs in the workplace, or at other locations.

The report also notes that Ontario's universities have a crucial role to play in the implementation of any such strategy as developers of the telecommunications infrastructure and technology testbeds, educators in information technology, sources of information technology, and sources of intellectual capacity, including highly trained human resources.

*Douglas Powell is with the Information Technology Research Center at the University of Waterloo.*

# Information technology sector generated more than $40 billion

**By Douglas Powell**

The Canadian information technology sector generated more than $40 billion in total revenue in Canada during 1990, employed more than 280,000 people and accounted for 35% of all industrial R&D expenditures.

These were the primary findings of the Information Technology Statistical Review, released earlier this year. The review was prepared by Industry Science and Technology Canada (ISTC) and based on data from Statistics Canada, private research companies and ISTC estimates.

Communications Canada and the Information Technology Association of Canada (ITAC) were consulted in the preparation of the document. The numbers show that the information technology sector grew at three times the rate of the national economy between 1986 and 1990. Expenditures on computers and peripherals more than doubled to $5.1 billion (Canadian dollars).

Canada's imports and exports of information technology products also increased. As a proportion of Gross Domestic Product, the value Canadians add to products and services, the information technology manufacturing sector now equals that of the pulp and paper industry, one of Canada's traditional economic engines.

Statistics Canada recently released industrial R&D numbers for 1982 to 1992, which also point to a continuing increase of R&D within the information technology sector. Among the highlights:

• Total R&D expenditures in Canadian industry are expected to exceed $5.2 billion in 1992, an increase of 1.6% over 1991.

• This increase is comparable to a 1.5% increase in 1991, but is much lower than a 6.9% increase in 1990. In real terms (after taking into account inflation), growth for 1991 was -1.1%, compared to 3.8% for 1990 and -1.0% for 1989.

• Telecommunication equipment is the leading industry with 15% of all intramural R&D expenditures, followed by aircraft and parts (8%), engineering and scientific services (8%), other electronic equipment (7%) and business machines (6%).

• Funding of industrial R&D from foreign sources was equivalent to 18% of the total industrial R&D, while the federal government's contribution was 8% and other Canadian sources accounted for 10%.

• Most of the industrial R&D in Canada was performed in Ontario and Quebec, with 56% in Ontario in 1990, where electrical and electronic products industries are prominent.

# IEEE Technical Committee on Parallel Processing is created

The IEEE Computer Society has created a Technical Committee on Parallel Processing (TCPP). The committee is chaired by Viktor K. Prasanna of the University of Southern California, and participants include CRA board members Mary Jane Irwin and H.T. Kung, who also will be chairing the Seventh International Parallel Processing Symposium (IPPS).

IPPS 1993 serves as the lead activity of the TCPP, and Prasanna will chair the event's program committee. The symposium will include workshops on heterogeneous processing and real-time distributed processing.

The formation of the TCPP acknowledges the importance of parallel processing technologies to the challenges of the coming decades and seeks to support advances in the tools and techniques which, when optimally combined, will enable high-performance parallel computing. For more information on the committee, contact E-mail: tcpp@halcyon.usc.edu.

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specific projects to professors.

Overall, there seems to be much less interaction between Japanese industrial research and Japanese academic laboratories than between the US equivalents. There is little technology transfer from universities to industry, and there are few joint research projects between Japanese academia and industry. Indeed, it is often observed that Japanese industry has stronger ties with top US computer science departments than with the top Japanese laboratories.

Comparing the quality of computer science research done in Japan versus that in the United States is tricky and subjective. Our opinion is that, on the whole, computer science is stronger in the United States. We did, however, see a number of credible research efforts in Japan, including those in such diverse areas as object-oriented systems, document recognition, software engineering and complexity theory.

### Lessons learned

Probably the most important lesson we have drawn from our experiences is that it is difficult to overestimate the influence of culture in distinguishing the structure of American and Japanese approaches to teaching and research in computer science. There are several noticeable differences between US and Japanese universities.

• The tendency of Japanese faculty to stay in a department, or even a laboratory, from the last year of undergraduate study through retirement differs from the more mobile approach in the United States.

• The narrow focus of most Japanese computer science research programs contrasts with generally broader US research programs.

• The structural leveling of resources, in general, contrasts with the wide variation across US departments.

• The marked absence of women and foreigners among faculty and graduate students contrasts with the more heterogeneous nature of US departments.

• The small number of faculty and Ph.D. students in top-tier Japanese programs contrasts with the much larger programs found in comparable US universities.

These differences still do not adequately capture the "feel" of academic computer science in Japan. The influence of Japan on computer science, as in other political, social and scientific realms, is growing. It is essential for us to learn about Japanese computer science in order to benefit from the work that goes on there and to improve our own work.

For a copy of the full article, contact David Notkin, Department of Computer Science and Engineering, FR-35, University of Washington, Seattle, WA 98195; E-mail: notkin@cs.washington.edu. Or contact Richard D. Schlichting, Department of

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## Research News

# Workshop focused on experimental CS research

BY **Barbara Liskov**

*This is the first of two articles.*

The Office for Naval Research sponsored a workshop last fall in Palo Alto, CA, on improving research in experimental computer science. The overall goal of the workshop was to identify problems and issues in experimental computer science and propose solutions. The workshop consisted of two parts and was cosponsored by the National Science Foundation, the Defense Advanced Research Projects Agency (DARPA) and other science agencies that participate in the Federal Coordinating Council on Science, Engineering and Technology (FCCSET).

Attendees met as a group for the first day and a half to identify problems and issues that required more detailed discussion. The remainder of the time was spent in small working groups that proposed solutions to specific problems.

The session summaries are documented in a technical report.[1] Session leaders reported on the discussions at the final session.

### General sessions

A panel opened the workshop with brief presentations by Robert Taylor of Digital Equipment Corp.'s Systems Research Center; Anant Agarwal of the Massachusetts Institute of Technology Laboratory for Computer Science; Richard Selby of the University of California at Irvine; Susan Owicki of DEC; and Paul Cohen of the University of Massachusetts at Amherst.

Taylor said that even though the state of computer science research as a whole has improved during his 30-year career, the number of university departments capable of doing first-class experimental research has increased only modestly. He said he believes that good experimental work requires that people build what they design and use what they build.

### Credit due

Agarwal said we should learn to reuse each other's work and replicate each other's results. Researchers should get credit for making their work available to others, because the competitive advantage represented by the tools produced by a group may be compromised by their early dissemination. Researchers also should get credit for using someone else's work, support for distribution of tools and support for the infrastructure needed to make reuse practical.

Selby said artifacts must be built and evaluated, but their construction requires a large amount of time-consuming engineering work. The work can be reduced by reuse, but only well-engineered and well-supported tools are worth reusing.

Owicki said the goal of performance measurement is not just to get numbers. Instead, performance measurement should identify the affect of particular approaches or techniques on performance to make informed decisions on its value. Because technology is changing rapidly, researchers must either get results quickly or abstract away from technology so results will survive changes, she said.

Cohen discussed the results of a survey of papers in AAAI-90, which said artificial intelligence needs more sophisticated experimental methodology. He said the conclusion can be made about all fields of computer science.

### Experimental work

The second session focused on experimental work outside of computer science.

**_Good experimental work requires that people build what they design and use what they build_**

Jim Plummer from Stanford University works on solid state and IC applications. It is expensive to build devices in his field, so simulation is used extensively before a device is built. Plummer said all experiments measure something, and all theories are wrong if pushed far enough. Simulations are only as good as the models on which they are based, and adequate models always arrive too late to simulate state-of-the-art devices, he said.

Publication of research in solid state and IC applications is centered around small experiments that are components of large projects. A few experiments might be packaged into a thesis.

The capital cost of equipment is extremely high, so laboratories and infrastructure must be shared, Plummer said. But even with sharing, the costs almost are more than can be borne by university faculty.

Jack Owicki, a scientist at the University of California, Berkeley, is working in an interdisciplinary area that includes chemistry, biology and physics. Performing experiments well involves more than just taking measurements; one also must figure out how to interpret the data, he said.

Owicki described the difference between hypothesis testing and "fishing expeditions"—premises that researchers hope will eventually raise hypotheses that can be tested. Model systems are useful for experimental work because they simplify reality when it gets too complicated, but the models create a tension between scope and fidelity. Owicki said the style of research varies in the different scientific disciplines. No field is broadly similar to computer science, although there are limited analogies in various areas, he said.

### Case studies

Workshop sessions were devoted to case studies of experimental projects. The presentations focused on the structure of the project and what was needed to make it work, rather than on the research content of the work.

Richard Anderson of the University of Washington described his work on using parallel algorithms to see how they perform in practice. He needed to access state-of-the-art multiprocessors. But because he had not used such processors often, he wanted to be able to share his work with others. In addition, he needed good measurement facilities; good infrastructure support such as programmers and systems experts; and knowledgeable colleagues to help him understand anomalies.

Hans Berliner of Carnegie Mellon University discussed the HiTech chess machine. This small project began as a student's idea. The amount of work required was greatly underestimated, but the project team had support from several staff members in the hardware laboratory at the university. The research focused on getting a particular program to work quickly, as opposed to studying specific techniques to identify their contribution to the project as a whole.

David Cheriton of Stanford University discussed the way the V-system project has served as a vehicle for systems research. He said a substantial research vehicle is needed to enable sophisticated experimental systems research. Such a vehicle brings problems to researchers' attention and allows them to tackle problems more easily than could be done in a more conventional setting.

Although many students worked simultaneously on the V system, the students tended to work one-on-one with Cheriton, rather than on group projects with other students. Cheriton found that there is a tension between the work needed to maintain the environment and make progress, and the need to free students to pursue their own research objectives.

M. Satyanarayanan of Carnegie Mellon discussed the differences between running a project using professionals and running one using students.

Professional staff put the needs of the project ahead of individual needs to do research, and they have fewer qualms about working together or reusing techniques they did not invent.

Students must do research and accomplish original techniques, and they have problems with taking credit for joint work (deciding what work goes into whose thesis). They do not fully appreciate simplicity, and their time is fractured because they have to take classes and exams. Their results will progress slowly, so students need to choose problems that are farther into the future.

### Systems research

Hank Levy of the University of Washington discussed systems research at the university. This type of research is unusual among academic institutions because of the large amount of faculty collaboration. Joint work is encouraged for the students: All papers have several authors, and the content of individual theses is worked out in a dynamic and flexible fashion. New projects build on the artifacts developed for older ones. The research methodology was to choose a problem, design a solution, choose the most efficient path to demonstrate that the solution works and analyze the results. Quick turn-around in building a prototype is important. Six months is an acceptable completion period; three years is not.

The Spur project at the University of California at Berkeley was discussed by Randy Katz and David Patterson (the project's principle investigators) and Susan Eggers, James Larus and David Wood (project students who now are on the faculty at the University of Washington and the University of Wisconsin at Madison). From the beginning, the goal of this broadly scoped project was a high-performance, working system.

Students were broadly educated. They understood systems, not just isolated components. Developing working prototypes gave students more knowledge in some areas than would have been possible using functional analysis. Students also gained valuable experience and broad exposure outside the university.

However, the students felt that they spent more time in school (up to 2.5 years) because of the need to complete the overall project. The use of professional staff was vital, because they provided continuity, had skills students lacked, freed students to concentrate on research and suffered less from personal and group tension.

The project might have progressed faster if the deliverables had been ideas rather than systems, and there might have been more chance to investigate alternative designs. None of the former students is doing research now on such a large scale.

When commercial RISC machines became available part way through the project, it might have been desirable to redirect the project away from the goal of producing a deliverable system. However, doing so would have caused problems because some students' research was contingent on continuing along the original path.

### The role of simulation

Douglas Clark of DEC discussed the benefits of simulation versus experimentation. Clark said simulation should be considered the primary tool for evaluation of a design, and hardware should be built only as a last resort.

Simulation has a number of advantages: It is cheap; it provides results quickly; it allows one to evaluate

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[1] Technical Report MIT/LCS/TR-540, MIT Laboratory for Computer Science, Cambridge, MA, June 1992.

## Research News

# AI, expert systems researchers honored in Canada

By **Douglas Powell**

The two winners of this year's Canadian awards for computer research excellence are researchers in the fields of artificial intelligence and expert systems.

The Awards for Academic Achievement were presented by the Information Technology Association of Canada (ITAC) and the Natural Sciences and Engineering Research Council (NSERC) to Geoffrey Hinton of the department of computer science at the University of Toronto, and Ching Suen, professor and past chair of computer science at Concordia University in Montreal [September *CRN,* Page 5].

Hinton, 44, was one of three authors of the seminal 1986 paper that introduced backpropogation, a technique for learning in neural networks that automatically constructs the features required for difficult tasks in pattern recognition. "Backpropogation is a particular algorithm for figuring out how to change the connection strengths in a neural network, so as to make the output of a network more similar to the required output," Hinton said. "What's so interesting is that it's relatively efficient for complicated networks, such as those that have many layers between the input and the output."

Backpropogation is now the most commonly used learning algorithm for neural networks used to control manufacturing processes, target business markets more precisely, guide vehicles and design medical devices.

A graduate of the University of Edinborough and formerly at Carnegie Mellon University, Hinton also is applying neural networks to recognition of speech, handwritten characters and even medical images such as pap smears, which typically contain about 500,000 cells. To determine if any of these cells are cancerous, an observer must decide whether an individual cell's nucleus is enlarged. Hinton devised "papnet," which uses a backpropogation network to pick out the 128 most suspicious looking cells from the 500,000.

"A human operator makes the final decision about whether these are really cancerous cells. Not only is this system faster, but it makes fewer mistakes because a person inevitably overlooks a few cells when facing such a huge number," Hinton said. "The backpropogation network can compute very fast once it has learned, so it can afford to look at all of the cells. As a result, the error rate in diagnosis has decreased by a factor of 10."

Hinton and his co-workers also have created a portable state-of-the-art neural network simulator called Xerion, first released in 1991, that is available to industry free of charge, with no restrictions on its use in products and with full access to the source code. More than 100 university and industrial research groups have received copies of Xerion. "The best way to transfer results from my research lab to Canadian industries would be to give them the software," Hinton said. "Make it all free. Then they can do what they want with it."

Hinton is the Noranda Fellow of the Canadian Institute for Advanced Research and serves as a consultant to Apple Computer Inc., E.I. du Pont de Nemours & Co. and Synaptics Corp. His essay, "How Neural Networks Learn From Experience," was published in the September 1992 *Scientific American*'s single-topic issue devoted to the mind and brain.

Ching Suen, an electrical engineer trained in bioelectronics and human/computer interaction, is a recognized leader in pattern recognition, expert systems and computational linguistics. As founder and current director of Concordia's Center for Pattern Recognition and Machine Intelligence (CENPARMI), Suen leads a 40-person research team with an annual research budget of more than $500,000.

Based on the concept of multiple expert systems, Suen has developed a sophisticated technique to recognize handwritten (and totally unconstrained) characters by combining human expertise with structural, morphological, neural and statistical methods.

"Because this is an area that mimics the human communication process—in this case, vision—it has something to do with expert systems. It tries to make use of human expertise, which is something very difficult to specify, in order to recognize patterns," Suen said. "Admittedly, it is hard to

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many different samples within a benchmark suite; it allows results to easily be replicated; it is flexible; and it can measure any aspect of the system.

But simulation also has disadvantages: Simulation always will be slower than the real machine; it is too slow for users to experiment with it; some workloads may be too small (because of the speed); it may not be accurate enough; and it might be wrong. Building a system may still be essential to overcome these problems. You must build something if you want to sell it, and students need to learn how to build boards.

However, simulations allow you to get your results sooner than if you actually built something only if fabrication is time-consuming. If the design takes most of the time, which is the case in many areas of computer science, simulation may be less helpful.

### Common themes

Several common themes arose during the workshop. Support is needed for several activities that aid research but are not deemed research by today's standards. We need help in building artifacts that are sufficiently robust and can be used with confidence. We need to find a way to encourage replication of results. We need infrastructure, such as shared equipment and professional staff, and money to buy tools. Support includes both funding and ways to give certain activities, such as replication, academic respectability.

It is clear that we have much to learn about doing performance measurements. Too often the numbers themselves are the goal, but numbers alone do not tell enough. We need to be able to evaluate and compare techniques in a way that isolates or neutralizes as many of the non-critical aspects as possible.

There are two distinct styles of experimental research. Often we experiment to prove or disprove a hypothesis. Sometimes we do exploration instead. It would be a mistake to rule out exploratory research on the grounds that it is not scientific enough. Experimental projects differ in other ways, too, such as in scale or in how real the result must be.

The primary task of students is learning how to do research, as opposed to doing research, or building, maintaining and distributing systems. Students need individual projects and unique solutions. There are many demands on their time, so progress is slower than it could be. Projects of any size need professional staff—not just to provide support for infrastructure, but to help build artifacts.

Simulation is a valuable tool, but it has a number of problems. A simulation runs too slowly to provide an artifact that others can use. The lack of such an artifact means that unexpected uses cannot be explored. Simulations are models, which may be incorrect or omit details that will be important if the system really were built. For certain areas it may be as fast to build the system as to simulate it.

Finally, it is unclear how far to go when building a system. To provide a tool with good performance requires tremendous effort, more than seems justified in many cases to achieve research objectives. However, good performance sometimes is required to achieve other goals, such as adoption or technology transfer.

*Barbara Liskov is a professor of computer science and engineering at the Massachusetts Institute of Technology and was chair of the workshop's program committee.*

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The Department of Computer Science has 25 tenure-track faculty members and 150 students in an expanding graduate program at the master's and Ph.D. levels. There are 450 students in the CSAB-accredited undergraduate program. The department has recognized research programs in the areas of artificial intelligence, computer communications and performance, graphics, parallel architecture, real-time systems, software engineering and theory.

The computer science faculty is involved in collaborative research in several NCSU centers including the Center for Communications and Signal Processing, the Precision Engineering Center, the Center for Research in Scientific Computation and the Integrated Manufacturing Systems Engineering Institute.

A land-grant institution with 27,000 students, NCSU is the largest university in North Carolina, located in Raleigh, the state capital. With Duke University and the University of North Carolina at Chapel Hill, North Carolina State University forms the Research Triangle, which has at its center a large industrial park of high-tech companies and research laboratories, including the Microelectronics Center of North Carolina and the North Carolina Supercomputing Center. This affords unique opportunities for academic and industrial collaboration. North Carolina State University is ranked sixth nationally in industry-sponsored research.

Raleigh lies in the North Carolina Piedmont, just a few hours east of the Blue Ridge Mountains and west of Atlantic beaches. The Research Triangle area boasts a high quality of life and moderate cost of living.

Applicants should send vitae, including a list of publications, and the names of four references to Chair, CSC Search Committee, Box 7901, North Carolina State University, Raleigh, NC 27695-7901.

Full consideration will be given to all applications received by Dec. 31. Informal inquiries may be directed to E-mail: search@csc.ncsu.edu.

NCSU is an affirmative action, equal opportunity employer.

**University of Illinois, Chicago**
*Electrical Engineering and Computer Science Department*
Instructorships and tenure-track faculty positions in electrical engineering and computer science at both the junior and senior level are available at the University of Illinois at Chicago. Rank and salary are commensurate with qualifications. Applicants for tenure-track positions should have an earned doctorate in electrical engineering or computer science by date of appointment. The instructorships do not require a doctorate degree. Demonstrated teaching and research abilities are highly desirable.

For full consideration, please send resume, list of publications, and the names of at least three references before April 30 to Dr. Wai-Kai Chen, Head, Department of Electrical Engineering and Computer Science (M/C 154), University of Illinois at Chicago, PO Box 4348, Chicago, IL 60680.

The University of Illinois is an affirmative action, equal opportunity employer.

**Concordia University**
*Department of Computer Science*
We are looking for a new faculty member with either a strong research record or excellent research potential to fill a tenure-track position at the assistant or associate professor rank. Applicants must be able to teach effectively at both the undergraduate and graduate levels. The successful candidate will be expected to carry out independent research and other academic duties associated with our bachelor's, master's and doctoral programs. Priority will be given to the following specializations: software systems, programming languages and parallel computing. However, truly exceptional candidates in all computer science areas are encouraged to apply.

The university is located in Montreal, which is well-known for its cultural diversity and beauty. The department houses about 600 undergraduate, 90 master's and 35 doctoral students. While the undergraduate program emphasizes both fundamental and practical skills, our graduate research focuses on artificial intelligence, combinatorics, computer algebra, databases, distributed computing, large-scale scientific computing, pattern recognition, programming languages, software engineering and VLSI architectures. There are 28 full-time faculty positions supporting these activities.

The department has established CENPARMI (the Center for Pattern Recognition and Machine Intelligence), which specializes in pattern recognition and related expert systems research. The research groups in mathematical computing and VLSI architectures also are members of two interuniversity research centers: CICMA (Centre Interuniversitaire en Calcul Mathématique Algébrique) and GRIAO (Groupe de Recherche Interuniversitaire en Architecture de Haute Performance et VLSI). In particular, CICMA promotes research in algebraic computing, combinatorics and computational group theory.

The department recently established a small parallel computing facility as a start-up platform to develop and focus interest in this area. We expect to upgrade this facility in the coming years. To promote the development of new faculty members, the university has a program to provide seed grants for their research during the first three years.

Interested applicants should send a resume and the names of at least three references to Chair, Department of Computer Science, Concordia University, 1455 de Maisonneuve West, Montreal, Quebec H3G 1M8, Canada. Fax: 514- 848-2830; E-mail: hiring@cs.concordia.ca.

Concordia University is committed to employment equity and encourages applications from women, aborigines, visible minorities and disabled persons. All things being equal, priority will be given to female candidates.

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

**University of Wisconsin at Madison**
*Computer Sciences Department*
The Computer Sciences Department at the University of Wisconsin–Madison invites applications for one or more tenure-track positions beginning August 1993. Applicants should have a doctorate in computer science, or a closely related field, with a demonstrated ability in relevant scholarly research. Of particular interest are applicants with research interests in operating systems, networks, parallel and distributed systems, artificial intelligence, and numerical analysis. Applicants in these areas will be considered for a position at the assistant professor level.

The department has active research projects in a broad number 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 three National Science Foundation Coordinated Experimental Research (Institutional Infrastructure) grants. The previous two projects emphasized loosely and tightly coupled parallel computing. Our new project, PRISM, addresses parallel processing on machines that offer credible paths to teraflop computing.

Research computing equipment is plentiful. The department has several hundred DEC, HP, IBM and Sun workstations, plus numerous file servers and special-purpose devices for computer vision and computer architecture. Equipment for research in parallel computing currently includes a Thinking Machines CM-5, three Sequent shared-memory multiprocessors, an Intel iPSC/2 Hypercube and a Tandem CLX multiprocessor. An Intel Paragon is scheduled to arrive early next year.

Applicants should submit a vitae and the names of at least three references to Chair, Faculty Recruiting Committee, Computer Sciences Department, University of Wisconsin–Madison, 1210 W. Dayton St., Madison, WI 53706. To ensure full consideration, material should be received by March 15.

The university is an equal opportunity, affirmative action employer and encourages women and minorities to apply. Unless confidentiality is requested in writing, information about applicants must be released on request. Finalists cannot be guaranteed confidentiality.

**University of Massachusetts at Amherst**
*Department of Computer Science*
The Department of Computer Science invites applications for up to three tenure-track faculty positions at the assistant and associate levels and several research-track faculty and postdoctoral positions at all levels and in all areas of computer science.

Applicants should have a doctorate in computer science or related area and should show evidence of exceptional research promise. Senior-level candidates should have a record of distinguished research. Salary is commensurate with education and experience.

Our department has grown substantially over the past five years and has 30 tenure-track faculty and eight research faculty, about 10 postdoctoral research scientists, and 160 graduate students. Continued growth is expected over the next five years. We have ongoing research projects in robotics, vision, natural language processing, expert systems, distributed problem solving, person/machine interfaces, distributed processing, database systems, information retrieval, operating systems, object-oriented systems, persistent object management, real-time systems, real-time software development and analysis, programming languages, computer networks, theory of computation, office automation, parallel computation, computer architecture, and medical informatics (with the University of Massachusetts medical school).

The department recently established a national center (CRICCS) for research on real-time, intelligent complex computing systems. We also have a major project (Project Pilgrim) with Digital Equipment Corp. on distributed, heterogeneous networks, an NSF/CII award in the areas of computer vision, distributed AI and real-time systems, and a five-year DOD/URI Center of Excellence in Artificial Intelligence.

To support our research, we have an extensive research computing facility, including more than 200 Sun, Digital Equipment Corp. VAXstation and DECstation, and Texas Instrument Explorer workstations, numerous servers, two Sequent Balance multiprocessors, a 4,096-node Connection Machine, a variety of graphics devices, both Salisbury and Utah/MIT robotic hands, a Denning mobile robot and a real-time testbed.

Send vitae, along with the names of four references, to Chair of Faculty Recruiting, Department of Computer Science, University of Massachusetts, Lederle Graduate Research Center, Amherst, MA 01003. E-mail: facrec@cs.umass.edu. The deadline for applying is Feb. 1. The University of Massachusetts at Amherst is an affirmative action, equal opportunity employer.

# Professional Opportunities

## University of California, Santa Barbara

*Department of Computer Science*

The Department of Computer Science at the University of California, Santa Barbara, invites applications for several junior and senior tenure-track faculty positions. Senior applicants should possess distinguished research records and the ability to attract research funding, while junior candidates must demonstrate exceptional promise. The College of Engineering and the department have embarked on a multiyear plan to strengthen the department in experimental computer science.

We are seeking applicants primarily in parallel and high-performance computation and communication. We also are interested in candidates in software systems. Responsibilities include conducting strong research, supervising graduate students, teaching graduate and undergraduate courses and participating in departmental and university committees. The department is part of an expanding College of Engineering, which encompasses more than 100 faculty in various disciplines. Excellent instruction and research computing facilities are available.

Applicants should hold a doctorate in computer science or related field. Appointments are scheduled to begin in 1993-94. Positions will remain open until filled. Send resume and names of at least four referees to Recruitment Committee, Department of Computer Science, University of California, Santa Barbara, CA 93106-5110.

The university is an equal opportunity, affirmative action employer.

## Pennsylvania State University

*Department of Computer Science*

The Department of Computer Science at the Pennsylvania State University is seeking qualified candidates for expected tenure track positions. Applications in all areas of computer science will be considered, with applicants in the areas of networking, operating systems and programming languages especially desired. Salary and rank will be commensurate with experience.

Applicants must have completed all requirements for a doctoral degree in computer science or a closely related area before assuming duties. Excellence in research and teaching is required. Candidates for senior positions must have an established research reputation supported by a substantial record of publications. Openings are expected for September 1993.

The Department of Computer Science maintains a Computer Systems Laboratory consisting of a distributed system of Sun and DEC workstations and file servers running Unix.

Applications should be received by March 31, but will be considered until suitable candidates can be identified.

Please send resume and the names of three or more references to Chair, Faculty Search Committee, Pennsylvania State University, Department of Computer Science, Box J, Whitmore Laboratory, University Park, PA 16802.

The university is an affirmative action, equal opportunity employer. Women and minorities are encouraged to apply.

## University of Tennessee

*Department of Computer Science*

The Department of Computer Science seeks to fill one tenure-track faculty position at the rank of professor, associate professor or assistant professor, as credentials warrant, beginning Fall 1993.

For a full professorship, a strong research record in the areas of operating systems, scientific computing or software engineering is sought, but all major fields in computer science may be considered. Experience directing doctoral students is especially important.

Applicants for associate professor should have a strong research record, preferably in the aforementioned areas; experience directing doctoral students is desirable. Applicants for assistant professor should have a strong interest in research, preferably in the aforementioned areas. Applicants for all positions should have a doctoral degree in computer science or a related area. Applicants should specify the rank for which they are applying.

Fully networked departmental Sun Microsystems, IBM and DEC workstations abound for students and faculty. The department has acquired a Thinking Machine CM-5. The department and the Mathematical Sciences Section of the Oak Ridge National Laboratory jointly operate the Advanced Computing Laboratory, which has several fully networked systems, including an Intel iPSC/860 with 128 processors, an iPSC/2 with 64 processors, two Sequent Balances and a Sequent Symmetry, a Stardent Titan with four processors, a Cogent, an N-Cube, a Kendall Square Research machine with 32 processors, and various file servers. Oak Ridge National Laboratory is acquiring an Intel Paragon. The university operates an IBM 3090 and a large VAX cluster.

The department recently received a National Science Foundation Small-Scale Infrastructure Award. The department is part of the NSF Science and Technology Center for Research in Parallel Computing.

Please respond to Search Coordinator, Department of Computer Science, 107 Ayres Hall, University of Tennessee, Knoxville, TN 37996-1301. E-mail: search@cs.utk.edu.

The University of Tennessee is an equal opportunity, affirmative action, Title IX/Section 504/ADA employer.

## Oregon State University

*Department of Electrical and Computer Engineering*

The Department of Electrical and Computer Engineering continues to invite applications for faculty positions in computer engineering. Associate and full professor positions require a distinguished teaching and research record appropriate for the title. Candidates should have an earned doctorate in electrical or computer engineering or in a related field and are expected to have a strong commitment to high-quality undergraduate and graduate teaching and to the development of a sponsored research program.

Applicants must have a distinguished teaching and research record appropriate for the title. Preference will be given to senior-level applicants with a strong research record and the ability to provide leadership in the computer engineering area. Areas of interest include high-performance computer architecture, parallel processing, VLSI array processing, performance analysis and data flow computing.

With a faculty of 25, the department enrolls about 425 undergraduate and 120 master's and doctoral students. The department offers ABET-accredited programs in electrical and computer engineering. High-technology corporations, including Hewlett-Packard, Intel, Mentor Graphics and Tektronix, have major operations in the area and provide support for the electrical and computer engineering programs. The department has modern facilities housed in a new building. Located in the Willamette Valley 80 miles south of Portland, OSU and the city of Corvallis offer a beautiful and unspoiled environment and many cultural activities.

Applications must include a comprehensive resume, a list of three to five professional references and a letter of interest that clearly indicates which position the candidate is applying for. Please send material to Chair, ECE Search Committee, ECE Department, Oregon State University, Corvallis, OR 97331-3211. Review began Nov. 1 and will continue until the positions are filled.

Oregon State University is an affirmative action, equal opportunity employer and complies with Section 504 of the Rehabilitation Act of 1973.

## University of Florida

*Department of Computer and Information Sciences*

The Computer and Information Sciences Department at the University of Florida invites applications for tenured or tenure-track positions at the senior and junior levels in the areas of software engineering, programming languages and parallel processing. Applicants must possess a doctoral degree in computer science or equivalent and show a strong record of and commitment to teaching and research in these areas. The positions are available at the start of the 1993–94 academic year.

Applicants should send their resumes and the names and addresses of four references to Professor Sartaj Sahni, Chair, Faculty Search and Screen Committee, Computer and Information Sciences Department, 301 CSE, University of Florida, Gainesville, FL 32611-2024. Tel. 904-392-1200; E-mail: sahni@cis.ufl.edu.

The closing date is Dec. 1, or until the positions are filled. The University of Florida is an equal opportunity, affirmative action employer. Women and members of underrepresented minority groups especially are encouraged to apply.

This faculty search will be conducted in compliance with Florida's Government in the Sunshine Law.

## University of Rochester

*Department of Computer Science*

The Computer Science Department invites applications for tenure-track positions at the rank of assistant professor. Outstanding candidates will be considered in any area of computer science, although applicants in systems particularly are desired.

Candidates must have received, or be about to receive, a doctorate in computer science or a related discipline, and must demonstrate exceptional potential for both research and teaching.

Our department is small (13 faculty), with a strong record of research publication and external funding. We offer an outstanding research environment, with excellent students and facilities, and an unusually close-knit and collegial atmosphere. Research interests include artificial intelligence (vision/robotics, natural language/knowledge representation), parallel systems and theory of computation.

About 40 students are enrolled in the Ph.D. program. There is no professional master's program. The department is planning to establish a selective undergraduate major.

Applicants should send a curriculum vitae, copies of relevant papers and the names and addresses of at least three references to Faculty Recruiting Committee, Department of Computer Science, University of Rochester, Rochester, NY 14627-0226.

The university is an equal opportunity, affirmative action employer, and it encourages applications from women and minorities.

## California Institute of Technology

*Department of Computer Science*

Caltech invites applications for a tenure-track position from candidates with promise for innovative research and teaching. Exceptionally well-qualified applicants may be considered at the associate or full-professor level. Initial junior faculty appointment normally is for four years and is contingent upon completion of a doctorate.

The Department of Computer Science seeks to strengthen and broaden its research and teaching program from its present strengths in concurrent computation, VLSI, computer graphics and formal methods of programming into complementary areas.

Please send a resume, list of publications, copies of your best publications and names of at least three references to Alain J. Martin, Chair, Computer Science Search Committee, Caltech 256-80, Pasadena, CA 91125.

Caltech is an equal opportunity, affirmative action employer. Women and minorities are encouraged to apply.

## Computing Research Association

### *Staff Policy Associate*

The Computing Research Association (CRA), a nonprofit association in Washington, DC, seeks a motivated staff policy associate with a computer science or engineering background and an interest in public policy.

In conjunction with the Association for Computing Machinery (ACM), CRA will be significantly expanding its coverage of public policy issues affecting the computing community. This entry-level position offers an exciting opportunity to be involved in policy-making, as it relates to computers and information technology.

Issues CRA currently is following include:

- Long-term changes in the way government supports R&D;
- The High-Performance Computing and Communications initiative, including the National Research and Education Network (NREN);
- Digital libraries; and
- Information policies, including privacy, security, intellectual property and public access to government information.

The associate will track the development of issues, perform research, attend meetings and communicate with experts in the field. Through written and oral communications, the policy associate and the executive director will inform the computing community about important issues. The associate will work with CRA and ACM committees to set priorities and strategies for further action, such as drafting letters and testimony, convening workshops and seminars, and developing position papers.

In addition to a computer science or engineering background, the associate must have excellent communication skills. Knowledge of the legislative process and public policy experience are a plus. A bachelor's degree is required.

The salary for this entry-level position is commensurate with that of similar policy jobs in the Washington area. CRA offers a good benefits package.

Send cover letter, salary requirements, resume and three appropriate writing samples to Fred W. Weingarten, Executive Director, Computing Research Association, 1875 Connecticut Ave. NW, Suite 718, Washington, DC 20009.

## Policy News

# Nagel: Gov't needs to refocus its R&D spending

*The following is an edited version of testimony given by David C. Nagel, the senior vice president for advanced technology at Apple Computer Inc., before the House Science, Space and Technology Subcommittee on Science.*

I am honored to appear before this subcommittee to offer Apple's views on the relationship of federal R&D activities to the private sector. Although I appear for Apple, I will draw heavily on research and analysis done by members of the Computer Systems Policy Project (CSPP), an affiliation of the chief executives of 13 leading US computer companies.

In 1991, CSPP companies had worldwide revenue in excess of $140 billion, 60% of which was derived from outside North America. Perhaps more than any other industry in the United States, computer systems producers—and the high-technology industry of which they are a part—are highly integrated into the global market system. There is possibly no other sector of the US economy that contributes so much to, and depends so heavily on, international markets for its domestic and international success.

The rapid pace of technological advancements and the computer industry's success in domestic and global markets makes it among the most fiercely competitive of US industries. In this highly competitive environment, the speed with which any given company can bring a new product to the market increasingly determines the success or failure of multimillion dollar investments and the maintenance or loss of thousands of jobs. Typically, computer systems manufacturers derive half their revenue from products that did not exist two years earlier. As a case in point, in 1991 Apple derived almost 85% of its revenues from products introduced in that fiscal year. These incredibly short product life cycles demand that the computer industry continuously develop new products based on innovative technologies.

The synergy between investment in R&D and the success of high-technology in industries is recognized by our international competitors. US companies compete with foreign companies that receive support from their countries' governments.

This support typically includes financial support and governmental commitments to setting national technology priorities and identifying important technologies that are strategically important to the economic well-being of the country.

Each company must take the primary responsibility for meeting the challenges posed by the current domestic and international environment. In response to a highly competitive global market, US computer companies: (1 ) invest steadily and substantially in R&D; (2) focus on commercial products; (3) emphasize quality; (4) compete enthusiastically in the most competitive and rapidly growing foreign markets; and (5) continually train and educate their work force.

The computer and semiconductor industries invest heavily in R&D; they account for more than 24% of all US industrial R&D spending. According to the June 29, 1992, issue of *Fortune Magazine*, six CSPP companies currently account for more than 13% of all exports generated by the country's top 50 exporters. More than 90% of these companies' R&D activities are conducted in the United States. CSPP companies spend more than $2.24 billion a year to educate and train their employees and to reach out to future generations of employees.

While the primary burden for competing successfully rests with industry, the federal government has a clear role to play. In 1991, total US R&D spending, both public and private, was $151 billion, of which the federal government spent $66 billion, or slightly less than half. This latter sum represents more than that of all of our major competitors' governments combined. Despite this fact, the United States needs to refocus federal R&D spending to better reflect new global realities and to realize a better return on investments.

Since the mid-1980s, more than 60% of the government's R&D spending has been devoted to defense research. Historically, the split in US government spending between defense and non-defense research was 50%. It is time to begin shifting back to the historical balance, or even beyond.

It also seems clear that government and industry should work together to increase the nation's return on the federal R&D investment. For example, while 24% of private industry spending was devoted to computer-related R&D in 1991, the government allocated only 2% of its R&D budget to such R&D. Our major competitors maintained a greater balance between public and private computer and communication industry investments.

CSPP is developing a set of recommendations to help improve national economic performance. CSPP believes that government and industry should work together to (1) increase the allocation of funds to commercially relevant technologies, (2) improve federal R&D budget review mechanisms and increase industry involvement, and (3) improve government incentives for US R&D.

***It seems clear that government and industry should work together to increase the nation's return on the federal R&D investment.***

CSPP strongly supports basic research. We also believe the federal government should work with industry to reallocate, over the next four years, up to $10 billion per year of its total R&D budget to support the development of pre-competitive, generic technologies. CSPP has applauded the recent High-Performance Computing and Communications (HPCC) initiative as a significant and critical undertaking by the government in this direction.

We have offered specific recommendations for strengthening this initiative and for increasing the focus of the program to better bring the benefits of the research and technology development to individual Americans and US industry.

CSPP, for example, has suggested that the HPCC initiative should be enhanced and expanded to provide the foundation for an information and communications infrastructure of the future and to bring the benefits of the HPCC technology to individuals in areas such as health care, education, lifelong learning and manufacturing.

In addition to science and engineering, CSPP believes that HPCC, and future programs like it, can play an important role by providing a framework of challenging national goals, goals which can catalyze, focus and direct the individual efforts of government and industrial R&D activities.

To examine how government and industry might work more effectively to achieve these goals and to maintain and enhance the health of American industry and our economy, it may be helpful to examine successful practices for commercialization of basic and applied research and technology development.

In a 1990 article published in *The McKinsey Quarterly*, the technical journal of an international consulting company with a history of working with the high-technology industry, the commercialization practices of the most successful companies were compared and contrasted with those of poor performers.

The best companies view commercialization as a highly disciplined system and establish it as a top priority; set measurable goals for ongoing improvement; develop the necessary organizational skills; encourage managers to take aggressive action; and bring their products to market in less than half the time of poor performers. The development of superior commercialization skills, then, are viewed as among the most important competitive challenges managers face.

I believe a similar set of principles could improve the return on federal R&D investment. Although support for basic research should remain among the top priorities of federal R&D managers for those programs with the greatest immediate potential for commercialization, the transfer of technology from government to industry should be given more emphasis and attention.

In many cases, legal barriers impede this transfer. CSPP recently negotiated with the Energy Department a model Cooperative Research and Development Agreement, which goes a long way toward removing some of these barriers.

The best method for transferring technology lies in linking those who perform the research and develop the enabling technologies with those who convert these technologies into products. Better methods must be found to encourage the interplay of scientists and engineers in universities and the national laboratories with companies attempting to harvest the results.

The federal government must play an increasing role in the scientific and technological health of America. If it does not develop more effective policies and programs, the US will lose more ground to aggressive and increasingly competitive foreign economies.

The companies of the CSPP, have demonstrated both a willingness and the ability to work closely with the government to implement the required changes. The result can be a more competitive and vital America.

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**Japan from page 7**

Computer Science, University of Arizona, Tucson, AZ 85721; E-mail: rick@cs.arizona.edu.

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*David Notkin is a professor of computer science and engineering at the University of Washington. Richard D. Schlichting is a computer science professor at the University of Arizona.*

**Award from page 9**

make a computer act like an expert. This happens because computers can get the specific knowledge from the expert but not the common knowledge. Despite this limitation, this has become the new focus of research in the area of pattern recognition."

A graduate of the University of British Columbia, Suen also helped introduce verification and validation techniques to expert systems in telecommunications.

His research in this area began four years ago when Concordia was awarded a four-year, $800,000 contract by Bell Canada to develop a unique set of guidelines to evaluate expert systems for diagnosing problems in communication networks and related applications.