COMPUTING RESEARCH NEWS

The News Journal of the Computing Research Association

March 1992 *Vol. 4/No. 2*

President requests 23% increase in HPCC spending

Table 1. HPCC Budgets by Agency and Program (in millions of dollars)

Agency	Fiscal 91 Actual	Fiscal 92 Estimated	Fiscal 93 Requested	1993 Funding by Program HPCS	ASTA	NREN	BRHR
DARPA	183.0	232.2	275.0	119.5	49.7	43.6	62.2
NSF	169.0	200.9	261.9	28.6	125.6	45.1	62.6
DOE	65.0	92.3	109.1	10.9	69.2	14.0	15.0
NASA	54.0	71.2	89.1	14.1	61.4	9.8	3.8
NIH	13.5	41.3	44.9	4.2	22.6	7.2	10.9
NOAA	1.4	9.8	10.8	0.0	10.4	0.4	0.0
EPA	1.4	5.0	8.0	0.0	6.1	0.4	1.5
NIST	2.1	2.1	4.1	1.1	1.0	2.0	0.0
Total	**489.4**	**654.8**	**802.9**	**178.4**	**346.0**	**122.5**	**156.0**

By Fred W. Weingarten
CRA Staff

For the second year, the president's budget proposal includes an increase in funding for high-performance computing and communications. The fiscal 1993 budget proposal increases HPCC funding to $802.9 million, a 23% increase over the fiscal 1992 enacted level.

Congress appropriated $654.8 million for the HPCC program in fiscal 1992. This was $16.5 million more than the administration originally requested.

Presidential science adviser D. Allan Bromley said in a statement issued when the budget was released, "This initiative will strengthen and extend U.S. leadership in all scientific and technological areas of high-performance computing and communications, and quicken the pace at which the technology is deployed. It will have a profound impact on science, business, government, education and society in general."

Bromley specifically acknowledged CRA's help in developing planning and management strategies for HPCC.

The interagency presidential initiative and its four basic programs were explained in a supplementary budget booklet, *Grand Challenges 1993*:

• High-Performance Computing Systems (HPCS) will accelerate the development of future generation high-performance computer systems.

• Advanced Software Technology and Algorithms (ASTA) will develop computational tools and resources for using high-performance computers, particularly in grand challenge research areas.

• The National Research and Education Network (NREN) will develop and support high-speed data communications networks serving research and education.

• Basic Research and Human Resources (BRHR) will support the underlying needs for basic research and education required for the HPCC program.

Table 1 shows the distribution of the requested funds among the agencies and programs. The National Science Foundation's $61 million increase was the largest in dollars and by percentage. NSF's HPCC budget increased 30%, the Defense Advanced Research Projects Agency's and the Energy Department's budgets both increased 18%, and NASA's budget increased 25%.

Tables 2, 3 and 4 (on page 6) show the change in emphasis on the programs in the fiscal 1992 and 1993 budget proposals for NSF, DARPA and all agencies. A breakdown of actual program expenditures in fiscal 1992 among the agencies participating in the HPCC initiative is not available, so this table is only an estimate. NREN and ASTA are receiving more attention this year. The amount NSF actually received for NREN in fiscal 1992 was several million dollars less than what was requested because of cuts in the foundation's appropriations. The 1993

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Inside CRN

Canadian networks slow by U.S. standards; but bandwidth increases are expected soon

By Douglas Powell
Special to CRN

If the United States and other countries have electronic superhighways then, as the metaphor goes, Canada has electronic cow paths.

The Natural Sciences and Engineering Research Council (NSERC), Canada's primary university granting agency, has allocated $538,000 (Canadian dollars) over the past three years in support of networking, or less than one-third of a percent annually of the U.S. commitment.

The lack of networking in Canada was a factor in the apparent demise of Canada's only university-based supercomputing center, the Ontario Center for Large-Scale Computation (OCLSC). Established in 1986 with provincial funding, the center will shut down March 31, unless the provincial government steps in once again.

A report for the Ontario government concluded that high-speed networking is important to researchers in many different ways, not only for large-scale computation. Networking bandwidth is a serious problem and needs significant attention and funding.

But as the United States embarks on a $3 billion, five-year, high-performance computing and communications initiative, which includes $400 million to construct the 1- to 3-gigabit/sec fiber-optic based National Research and Education Network (NREN), some encouraging news is emerging in Canada.

CANARIE, the Canadian network for the advancement of research, industry and education, is a five-year, $60 million undertaking that will begin to redress what many see as a severe shortcoming in a country that prides itself on leadership and innovation in the area of telecommunications.

Also, new legislation unveiled in late February will bring all of Canada's provincial telephone companies under one regulatory umbrella, encourage competition and ultimately may lower tariff rates. It costs three times more to transmit at high speeds from Vancouver to Toronto than it does from Los Angeles to New York.

High tariffs for long distance data communications often are cited as the main impediment to advanced networking in Canada. A coalition of business, academic and government representatives is spearheading CANARIE, under the auspices of the federal ministry, Industry, Science and Technology Canada (ISTC).

According to the plan, CANARIE would move key sections of CAnet, the existing national backbone, from transmission rates of 56 kilobits/sec to T1 or multiple T1 as quickly as possible. At the end of the proposed five-year project, T3 rates would be in place on at least the important links. NSFnet, the largest U.S. research network, recently was upgraded to T3.

Andy Bjerring, director of computing and communications services at the University of Western Ontario, said CANARIE also would include a test-bed network that would enable industry to develop and test products and support those in public and private sectors who are developing applications and services on the network.

"The awareness of the need for Canada to do something in the

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Opinions

Has CS changed in 20 years?

BY David A. Patterson

Computer science has changed dramatically in 20 years. Inventions since 1970 include microprocessors, DRAM, local area networks, PCs, workstations, the reduced instruction set computing architecture (RISC), portable operating systems, NP completeness, retargetable compilers and supercomputers.

Other achievements include a thousand-fold improvement in price-performance since 1972; a thousand-fold increase in the capacity of a dynamic RAM chip since 1977; and a 60% per year performance improvement in the fastest RISC workstation every year since 1987.

But in many aspects, computer science has not budged. The titles of computer science courses today essentially are unchanged since I was an undergraduate. Computer science is characterized by radical change, yet our educational systems have huge inertia. I do not mean to suggest that the contents of these courses have not been updated in 20 years.

My question is whether the undergraduate focus as expressed in the course titles still make as much sense in 1992—or 2020—as it did in 1970. Without energy to overcome inertia, it is likely that we will be teaching computer science tomorrow much as we have taught it in the past.

For example, although the computer science undergraduate curriculum has expanded to include elective courses in artificial intelligence, databases, software engineering and theory, we have not contracted our core curriculum to allow students to take many new classes. Newer ideas that may not be covered in computer science curriculum include networking, 3-D graphics, user interfaces and concurrent programming. Topics that may merit inclusion in the next several years include neural nets and fuzzy logic. Where is there room to expose students to any of these topics?

It is practically criminal that computer science students have a complete lack of exposure to programs of use outside the computer industry. It is a sad state of affairs that the only useful program that a computer science student is likely to "write" is a sorting program in a theory class. This introspective slant has meant that developments in the use of computers have passed us by—to the detriment of both parties. Spreadsheets, which Alan Kay called the most important innovation in programming languages in 20 years, are just one example.

Computer science students do not even have the opportunity to learn other fields during their time on campus. This is especially important because many exciting opportunities in the next decades will occur at the interface of computer science and other disciplines. Computer science has the opportunity to play a leading role in genetics and earth science. Will computer science students be allowed to get the educational foundation to participate?

Let's examine some specific examples of contracting the traditional computer science curriculum.

First I question why many computer science students are required to take courses in compilers and operating systems when the goal, at least as espoused in the popular textbooks, is learning to write your own compiler or your own operating system. As we head towards the next millennium, software engineering or graphical user interfaces might be just as important a foundation.

> ***"It is practically criminal that computer science students have a complete lack of exposure to programs of use outside the computer industry."***
>
> ***—David Patterson***

There has to be common principles for some fields that can be taught in a single course, such as a software systems course where enhancing databases, networks and operating systems are just hands-on examples of applying more general principles. Being more flexible on requirements and combining traditional topics would be a first step toward contracting our curriculum to allow computer science students to broaden their education.

A second place to look for contraction is in the introductory programming course. Why not require introductory programming only of freshman with no prior programming instruction? Forcing students who have been programming since junior high school to take an introductory programming course will bore the students and waste time.

Math departments do not start teaching every freshman algebra and trigonometry because of fear that the subjects were not taught well in high school. Math offers formalized tests that earn students credit for the first calculus course.

One computer science curriculum example is here at Berkeley. Students with a year of high school programming are expected to skip the first programming course. Eighty percent of the students go directly to our second course.

A third opportunity is in assembly language programming. Advances in programming language, compiler quality, memory size and processor speed almost have eliminated the practice of assembly language programming. OS/2 may be the last operating system to be written originally in assembly language. Delays in shipping OS/2 were due in part to rewriting it in C. All of the popular PC software is now in C.

It may be tempting to eliminate the assembly language course, but students need some understanding at this level to be able to take classes in compilers, operating systems or computer organization. Because there is widespread agreement that we do not need to teach as much assembly language programming as we did in 1970, this is one obvious opportunity for contraction if we combine it with the right course.

It is easy to be a critic, but how can you really overcome educational inertia?

I tried to do this five years ago for a computer literacy course, by offering a one-day workshop where we gave away items such as software, lecture notes, exams, projects and demos. About 100 faculty, representing at least 50 institutions, attended. They were interested in the ideas, but they made it clear that without a textbook there was little chance they would change. This workshop had almost no impact on overcoming educational inertia.

I had the opposite experience with the book on computer architecture John Hennessy and I wrote. We were extremely dissatisfied with the survey or chronological approach to teaching computer architecture. Our book offered a quantitative foundation for making decisions in computer design and explained the alternatives on key points. We never organized a workshop based on the book's ideas, yet this book is used in more than 200 institutions.

Moreover, we can have worldwide impact because there are economic incentives for others to translate the material into their native languages. (Having all the text and figures on a Apple Macintosh also helps.) *Computer Architecture: A Quantitative Approach* was published in 1990 and already has been translated into French, with translations under way for Chinese, Japanese, Italian and Spanish.

Hence, it is clear that to transfer ideas you need to write a book. Workshops are thought-provoking and even may be inspirational, but without a book, there is little chance of educational "technology transfer." This is a classic chicken and egg problem because, as tempting as it is to change the curriculum, it is hard to do without a book. Yet publishers are wary of new books without established curriculum. Letting publishers know that instructors are interested in new curriculum would be an important first step in making changes.

But to offer new courses, we need new books. So this article is primarily a call to authors. Is it unreasonable to expect a textbook on software engineering where the compiler writing is an example, rather than vice versa? How about a book that combines the

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Education News

CRA Board of Directors Nominations

CRA is seeking nominations for its board of directors. Candidates do not have to be CRA members. Board members are expected to actively participate in the organization and attend at least two board meetings each year at their own expense. Board members serve a three-year term.
Please contact the person you are nominating before you submit their name. We must receive this form and a brief biographical sketch of the nominee on or before March 31.

Information on nominee (please type or print):

Name _____
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Organization _____
Department _____
Address _____
City _____ State _____ ZIP code _____
Telephone _____ E-mail _____

Information on nominator (please type or print):

Name _____
Position _____
Organization _____
Department _____
Address _____
City _____ State _____ ZIP code _____
Telephone _____ E-mail _____

Please send this form and a brief biographical sketch of the nominee to:

CRA
1625 Massachusetts Ave. NW
Suite 110
Washington, DC 20036-2212

You can fax the information to us at 202-667-1066. For more information contact Fred W. Weingarten at weingarten@cs.umd.edu or 202-234-2111.

I _____ nominate
_____ to be a member of the CRA board of directors.
Signed _____ Date _____

Georgia Tech's College of Computing sets sights on playing leadership role

BY Molly Ford Croft

In July 1990, the Georgia Institute of Technology created the College of Computing to provide academic and intellectual leadership in computing for the campus and community. The college evolved from the School of Information and Computer Science, which was founded in 1963 with the sponsorship of the National Science Foundation.

Peter A. Freeman, dean of the college and vice chair of CRA, said the mission of the college is to "provide the human resources, technological advances and scientific understanding necessary for successful computing in the 21st century." The college's guiding vision is an organization that has mainstream computer science at its core, creatively mixed with other disciplines in strategic application areas, such as scientific visualization and communications. Freeman said he sees this as a "third-generation" organization evolving out of stand-alone computer science departments (the second generation) and programs within other departments (the first generation).

"Organizing a College of Computing with a strong interdisciplinary focus allows the computing program to build effectively on the strengths of Georgia Tech, through linkage to engineering and science researchers who are involved in the kinds of challenging applications that continually have pushed the frontiers of computing," Freeman said. "The college has a continuing strong core in computer science, along with programs that merge computer science with psychology, electrical engineering, cognitive science, telecommunications, management and graphics."

Professor Alton "Pete" Jensen, who served as acting director of the School of Information and Computer Science during its transition into the college, said, "Our charge was the formation of a college that will position Georgia Tech for national and world leadership in the future with a clear, definite identity in computing. Since the formation of the college in the summer of 1990, we have taken a proactive role, infusing the information technology throughout the institution. The faculty members have turned their attention outward, to find out what their role is with all the other disciplines."

The college awards bachelor's, master's and doctoral degrees in computer science, and has strong instructional and research programs in software engineering, cognitive science, artificial intelligence, distributed systems and databases, graphics and visualization, telecommunications and networking, parallel computing and computer architectures.

The college is comprised of an academic faculty of 37, a research faculty of 15 and an enrollment of about 130 Ph.D. students, 100 master's students and 500 undergraduate students.

Molly Ford Croft is the assistant director of development in the College of Computing.

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important principles of operating systems, databases and networks, where the programming assignments consist of modifications to working examples? When will parallel programming principles be spread throughout the curriculum rather than be offered as a separate advanced course? And must theory forever be taught distinct from practice?

One clear opportunity is a book that combines computer organization and design with assembly language programming. It could save time and space by assuming students know how to program in a high-level language and successively refining the programming language into assembly language. Assembly language is just another programming language, with restrictions not found in C or Lisp. It also would teach just enough assembly language to lay the foundation for subsequent courses.

Emphasizing computer organization while covering assembly language programming enables instructors to combine assembly language and computer organization courses. This would free computer science students to broaden their education.

It is clear that understanding the foundations of caches, virtual memory and pipelining have longer-term value than mastering the assembly language programming of a complex architecture. In fact, John Hennessy and I are so convinced of this need that we are writing a book defending that opinion.

You may agree or disagree with my specific suggestions, but computer science faculty must continuously re-evaluate how we teach this fast-moving field if our educational system is to avoid aging into an antiquated curriculum irrelevant to the exciting opportunities in computing.

Thus I challenge everyone to participate in a national debate on computer science education. Such a debate will help identify books that are available, soon to be available or that should be written. Better books are the path to a better computer science education.

It is always a gamble when authors do not follow traditional curriculum, but if some authors do not gamble, I fear the curriculum I took as an undergraduate will be what I teach until I retire.

As James B. Conant said, "Behold the turtle. He makes progress only when he sticks his neck out." I invite forward-thinking computer scientists to stick their necks out and join our quest.

David A. Patterson is professor and chair of the computer science division in the department of electrical engineering and computer science at the University of California at Berkeley. He also is a member of the CRA board of directors.

1993–94 Fulbright competition opens

Applications are available for the 1993–94 Fulbright Scholar Program. The Fulbright program includes about 1,000 grants for research, combined research and lecturing in more than 120 countries. Eligibility requirements include U.S. citizenship and a doctorate degree or comparable professional qualifications.

For more information, contact the Council for International Exchange of Scholars, 3007 Tilden St. NW, Suite 5M, Box NEWS, Washington, DC 20008-3009. Tel. 202-686-7877.

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Expanding the Pipeline

CRA committee is creating a database of women scientists

BY Joan Feigenbaum

By now, almost everyone in computer science research at one time or another has been involved in a discussion about women in computing. During these discussions, the following statements, or equivalent ones, probably have been made:

• We wanted to have a woman give the distinguished lecture at last year's conference, but there just were not any qualified women available.

• Our department wants to hire a woman, but all of the good women on the market are in theory and artificial intelligence, and we are not hiring in those areas.

• There is no bias against women in our field. If anything, women have an advantage. For example, every program chair has to put a woman on his committee; so every qualified woman has been on a committee, but not every qualified man has.

You probably also have observed this phenomenon: In each research area, there are one or two very prominent women. Every time there is an opportunity to dole out prestige of any sort, these one or two names are the first that come to mind. The person or committee doing the honors does not bother to find other worthy individuals who, for whatever reason (probably luck), are not as famous as the luminaries. If one of the luminaries is further honored, it makes her all the more prominent and makes everyone else all the more unlikely to be considered next time. And, yes, I know this also happens with men.

How could one argue effectively that there were, in fact, several women qualified to give that distinguished lecture, that there are some good women on the market in numerical analysis or software engineering, or that, despite tokenism, it just is not so that all of the qualified women have been on program committees? For that matter, how could the person making one of these claims about lack of qualified women or lack of bias support the claim with facts? Finally, what would help awards committees, program chairs, editors-in-chief of journals and others in a position to dole out prestige consider the candidates fairly, rather than choosing the first couple of people who come to mind?

Start with facts

Obviously, discussions of which women are available, in which fields and at which levels, should start with facts, rather than with stereotypes and anecdotes. At this time, there is no standard, easy way to obtain the facts. For this reason and others, the Computing Research Association Committee on the Status of Women (CRACSW) is compiling a database of female computer scientists in the United States and Canada. In this initial stage of the project, a woman must fall into one of the following three categories to be eligible for inclusion in the database: (1) she must have a Ph.D. in computer science or computer engineering; (2) she must have a Ph.D. in a related field, such as mathematics or electrical engineering, hold a full-time research or teaching position and identify her primary area of interest as computer science or computer engineering; and (3) she must be a graduate student currently enrolled in a Ph.D. program in computer science or computer engineering

The scope of the database may be expanded later. For example, it may be desirable at some point to include masters-level women in addition to the Ph.D. recipients. Ultimately, it would be great to have a database of all computer scientists—both men and women—so one could make accurate statements not only about how many women there are in category X, Y, or Z, but also what percentage of the people in category X, Y, or Z are women, or Californians, or graduates of the University of Michigan or whatever. A project of that size, however, would require far more than the resources available to the CRACSW and would have to be sponsored by a larger organization (perhaps the Association for Computing Machinery?). Nonetheless, in order to be prepared for this expansion, we have included a gender question in our questionnaire.

Voluntary inclusion

Of course, inclusion in the database is voluntary. In order to be included, a woman must fill out the questionnaire and send it to me. I will do my best to see that every eligible woman receives a questionnaire, for example, by contacting Ph.D.-granting departments and asking them to send the questionnaires to their eligible faculty, students and alumnae. But the departments will not provide the information for the database. The women themselves must voluntarily provide the information.

We would like to include women from outside of the United States and Canada. Our current policy is that a country may be included in the database if there is a woman in that country willing to assume the responsibility of collecting the data. Part of this responsibility will consist of translating the questionnaire and making sure the degree requirement is analogous to the American or Canadian Ph.D. degree.

CRA will maintain the complete database at its office in Washington, DC. In addition, our committee will put together a public version of the database and distribute it widely, either in book form or on floppy disks or both.

Protecting privacy

CRACSW is taking steps to protect the privacy of the database participants in two ways. First, women may request privacy for any of their answers. If an answer is marked as private, it will be stored only in CRA's central database and used only for statistical purposes. Second, a list of categories of anticipated users is included on the questionnaire, and

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Database Questionnaire

Please complete the following questionnaire and send it, preferably by electronic mail, to: Joan Feigenbaum, AT&T Bell Laboratories, Room 2C-473 600 Mountain Ave., P. O. Box 636, Murray Hill, NJ 07974-0636. E-mail: jf@research.att.com

You have the option of marking any of your answers as private. Private answers will be stored in the central database at CRA and used only for statistical purposes. Answers that are not designated as private will be included in a publicly distributed database.

1. Name _____
2. Gender _____
3. Birth date _____
4. Citizenship _____
5. Affiliation _____

If affiliation is a university or college, is it Ph.D.-granting? _____

If your department has more than one division (e.g., it is a CS/EE department with a CS division and an EE division), what are the names of the division, and which one are you in? _____

_____

6. Title _____

If Ph.D. student, when is your expected graduation date? _____

7. Postal address _____
8. E-mail address _____
9. Telephone _____
10. Fax _____
11. Ph.D. _____

Year _____

School _____

Department _____

If the department had more than one division, what were the names of the divisions, and which one were you in? _____

_____

Adviser _____

12. Bachelor's degree _____

Year _____

School _____

Department _____

If the department had more than one division, what were the names of the divisions, and which one were you in? _____

_____

13. Technical area. Select one or two of the following:

(A) Architecture
(B) Artificial intelligence
(C) Computer-aided design
(D) Databases
(E) Distributed computing
(F) Graphics and modelling
(G) Hardware
(H) Networks and communications
(I) Numerical analysis
(J) Parallel computing
(K) Programming languages
(L) Robotics or vision
(M) Software engineering
(N) Software systems
(O) Theory of computation
(P) Other — please specify

For each of the areas you selected, you may supply up to three subareas of your own description. _____

_____

14. Publications: Supply complete references for up to five representative publications. Please avoid using acronyms and abbreviations. Please attach to this form.

15. Are you willing to have your name listed in our speakers database? If so, please indicate which of the following types of audiences you are willing to address. Supply up to three representative talk titles. For each title, include the letter(s) of the appropriate audience type(s) and a one- or two-sentence abstract. Please attach to this form.

(A) Kindergarten through 6th grade
(B) 7th–9th grades
(C) 10th–12th grades
(D) Undergraduates
(E) Computer scientists, general
(F) Computer scientists, specializing in my field
(G) General scientific audiences
(H) Business audiences (indicate specific type, e.g., "marketing," "management", if desired)
(I) Other. Please specify.

16. Are you a member of one of the following groups?

(A) African American
(B) Female Asian Pacific Islander
(C) Hispanic
(D) Native American
(E) Other — please specify
(F) Prefer not to identify

17. The database may be used by the following categories of people and organizations. Check each one to which you grant access to your record. If you are willing to grant access to all users approved by the committee, check category (F). The answers you have marked as private may only be accessed by users in category (E), even if you grant general access to users in other categories.

(A) Employment search committees
(B) Conference organizers, program chairs, journal editors-in-chief, and similar project leaders
(C) Awards committees
(D) Service committees (such as CRA's)
(E) Scholars and committees studying women in computing
(F) All users approved by the committee

Expanding the Pipeline

Database from page 4

women are asked to specify to whom they would like to make their records available. Undoubtedly, we are unaware of many legitimate and interesting uses of this data, and that we probably will not realize its full potential until all the data is collected.

For this reason, participants may grant access to all users approved by the committee, and we hope most participants will choose that option. All requests to use the central database will be screened by CRACSW, to ensure that participants' privacy is respected and the proposed uses of the data are legitimate.

Broadly speaking, we foresee two general purposes for the database: statistical and recruiting.

Statistical users will include people doing studies of women in computing or women in science in general. These will be users who are not interested in the women's identities, but rather in demographics and other statistics. These users will be able to use the central database for large-scale searches.

On a smaller scale, all computer scientists can become statistical users. Next time you are embroiled in a discussion in which someone claims, "There aren't any women in my field who are qualified to give the distinguished lecture," "All of the good women candidates are in theory or AI" or "Every qualified woman has been on a program committee, but not every qualified man has," you and the people you are talking with will be able to look up relevant facts in the public version of the database.

Recruiting users of the database will include hiring committees, program chairs, awards committees and editors-in-chief of journals, all of whom may use the database as a resource in their search for qualified candidates. We hope that the existence of a standard, easy way to find out who all of the women candidates are will make it more likely that the one or two well-known women in a field are not the only ones recognized.

On a less formal level, the public version of the database may be used to find colloquium speakers, panel members and participants for regional events.

So far, we have distributed the questionnaire via several electronic mailing lists and to all department chairs that we had addresses for. As CRN went to press, I have received responses from more than 370 women. One of the hardest groups of eligible women to reach seems to be Ph.D. alumnae who no longer are working in basic research. Only one of the departments we contacted had an easily accessible list of alumnae addresses and offered to mail the questionnaire to all of the women on the list.

So we particularly are interested in enlisting the help of department chairs in contacting their alumnae and in receiving your suggestions about effective ways to reach such women. We hope you will help us by circulating a copy of this article and the questionnaire to all the eligible women you know.

Joan Feigenbaum is a member of the technical staff in the Computing Principles Research Department at AT&T Bell Laboratories in Murray Hill, NJ. She has a doctorate in computer science from Stanford and a bachelor's of arts in mathematics from Harvard. Her research interests include complexity theory, cryptography and computer security, and graph theory and applications.

Study: girls face bias in public schools

A gender bias in the classroom against girls first occurs in preschool and continues through high school, said a study released by the American Association of University Women.

"Gender bias undermines girls' self-esteem and discourages girls from courses of study, such as math and science, needed in the work force today," the study said. "Whether one looks at achievement scores, curriculum design or teacher-student interaction, it is clear that our schools are shortchanging America's girls."

Many girls in high school already have been pushed toward traditional female jobs and away from studying subjects that will lead to high-paying jobs in science, technology and engineering.

The study found that females receive much less attention from teachers than teachers give males, the gender gap in science may be increasing, and even females who are competent in math or science are much less likely than males to pursue scientific or technical careers.

Females who do pursue the math or science fields said teacher encouragement is very important. Exposing females to more real-life experiences with scientists and science also can increase the percentage of girls interested in those fields, the study said.

ACM hosts mentoring workshop

An Association for Computing Machinery and National Science Foundation workshop Feb. 6 in Washington, DC., brought together potential mentor and protege pairs from several academic and industrial organizations. The focus of this workshop was how longtime computer professionals could serve as mentors to people new in the field.

The mentoring workshop was part of an NSF-sponsored mentoring project to develop training materials for woman and minorities in computer science, set up pilot programs, determine how effective mentoring is in changing attitudes and produce mentoring materials and guidelines.

Participating organizations were the University of Oklahoma, George Mason University, the Georgia Institute of Technology, Martin Marietta Energy Systems, Mitre Corp. and TRW Inc.

The ACM Committee on the Status of Women and Minorities is overseeing these efforts. Shari Lawrence Pfleeger, principal scientist at the Mitre Corp., is chair of the committee.

News from the CSTB

By Marjory Blumenthal

The Computer Science and Telecommunications Board recently released a new report, *Keeping the U.S. Computer Industry Competitive: Systems Integration*. The report is based on an invitational colloquium involving senior executives, government officials and academic analysts. This was the second such colloquium CSTB has organized to consider issues arising from competition in the computer industry.

The report notes that, while U.S. businesses excel at systems integration, this is an area that lacks a strong base in academic research. Topics discussed in the report include the evolution of applications and the interplay among technology, process redesign and people; the importance of communications and software to the systems integration progress; concerns about the ability of the United States to influence international standardization activities; the potential for the High-Performance Computing and Communications (HPCC) program to advance systems integration; and the need for long-term, strategic commitments by industry and government to achieve the promise of systems integration.

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Last November, CSTB organized a workshop on advanced computer visualization and simulation. It brought together scientists and engineers from multiple disciplines to talk about their experiences and needs. A summary paper is being developed.

❑ ❑ ❑

CSTB is launching a study of academic careers for experimental computer scientists. The study will assess the value of experience across the discipline as the basis for evaluation for tenure and support for experimental work in computing. Building on the evidence it collects, a study committee will develop recommendations for nurturing subdisciplines and identify successful models that might be emulated.

❑ ❑ ❑

A number of new projects are being developed or planned. Two are particularly worth noting. First, CSTB and the National Research Council's Committee on Human Factors are developing a project that would generate a national research agenda for virtual reality. An unusually well-attended planning meeting that involved several government agencies was held in mid-January, and proposal preparation is under way. Also under development is a workshop series that annually would bring together cross-sections of the community on topics pertaining to the HPCC program.

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Progress continues in several on-going projects: reports are expected to be released this summer on the scope and direction for computer science and engineering, and human resources in computer science and engineering. Other projects under way include the effects of information technology on productivity and performance in services; movement toward a national collaboratory capability; and systems modernization at the Internal Revenue Service and Social Security Administration. CSTB's next strategic forum will address rights and responsibilities for participants in public data networks. A steering committee is being selected.

For more information about CSTB projects, contact Marjory Blumenthal at the Computer Science and Telecommunications Board, National Research Council, 2101 Constitution Ave. - HA/560, Washington, DC 20418. E-mail: mblument%nas.bitnet@cunyvm.cuny.edu.

Marjory Blumenthal is executive director of the Computer Science and Telecommunications Board.

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networking area is very, very high," Bjerring said. "There is a strong likelihood that 12 months from now we will see significant bandwidth increases on CAnet links."

Four working groups are studying business; network architecture and design; governance and regulatory affairs; and marketing. These working groups recently pooled their initial summations to create a business planning framework document, which sets the guidelines for an implementation plan. A full business plan should be completed by the end of April.

Pat Sampson, director of technology applications at ISTC, said that once the implementation plan is complete, the group will go back to the federal cabinet for a confirmation of funds. ISTC already has budgeted $13.7 million, or 25% of the project's total costs. The remainder will come from other federal departments, provincial governments, regions, users and industry.

William Hutchison, a managing partner at Toronto-based Ernst and Young and chair of the CANARIE executive committee, said the key outstanding issues are the relationship between the existing CAnet and the proposed CANARIE (or whatever the network is eventually called), and funding issues involving the provinces and industry.

"I have a bit of money set aside,"

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request is 38% higher than the 1992 request.

ASTA is receiving greater attention from all agencies, including user agencies such as the National Oceanographic and Atmospheric Administration, the National Library of Medicine and the Environmental Protection Agency.

This emphasis on applications and infrastructure building reflects the view of many policymakers that the program, in order to justify its funding increase, must have a major impact on users and make new high-performance systems more accessible, usable and practical.

Basic computer science and engineering have played and will continue to play a major role in the HPCC initiative. If the initiative is successful, however, the principal beneficiaries will be outside the computing disciplines.

The significance of the initiative for computer science and engineering may not be more research funds. Rather, it may be in establishing closer ties among computing researchers and the academic and industrial user communities that are developing more complex and challenging problems for high-performance systems.

The HPCC program may run into a few snags this year. Some Washington policy experts believe the political climate affecting science and technology appropriations will be harsher during a presidential election year. But with all the attention on the economy, many politicians are stressing long-term structural solutions, including a focus on education and R&D. HPCC supporters will have to watch carefully as each agency's bill, and particularly NSF's bill, moves through Congress.

Industrial and academic supporters are questioning several aspects of the initiative. For example, some supporters are not sure the HPCC program is being coordinated and run in a way that will maximize the technology flow from federally funded research projects to the computer and software industries.

NREN's future also is being debated. Several management and development questions remain unanswered.

Is NREN being adequately coordinated, both among the agencies charged with developing it and the government, academic and industrial users of NREN? What is the long-term management structure for NREN?

What is the proper relationship between a federally subsidized NREN and private sector providers? What plans, if any, are there for private and commercial NREN services, and how will the private carriers be involved in NREN development?

These questions arise only because of the success of HPCC and Internet. No one fights over losers.

Some policymakers and technology experts believe the future of this country will depend on the rapid deployment of a modern digital information infrastructure.

Seen in this light, HPCC politics, particularly NREN politics, are not really that far removed from the current debate among telephone companies, cable companies and newspaper publishers about the future of broadband digital communications.

Table 2. NSF HPCC Program Requests in FY 92 & 93
(in millions of dollars)

	HPCS	ASTA	NREN	BRHR
1991 Request	24.0	103.0	32.7	53.3
1992 Request	28.6	125.6	45.1	62.6
Dollar Change	+4.6	+22.6	+12.4	+9.3
Percent Change	19%	22%	38%	17%

Table 3. DARPA HPCC Program Requests in FY 92 & 93
(in millions of dollars)

	HPCS	ASTA	NREN	BRHR
1991 Request	103.3	38.5	32.9	57.5
1992 Request	119.5	49.7	43.6	62.2
Dollar Change	+16.2	+11.2	+10.7	+4.7
Percent Change	16%	29%	33%	8%

Table 4. Total HPCC Program Requests in FY 92 & 93
(in millions of dollars)

	HPCS	ASTA	NREN	BRHR
1991 Request	156.8	265.1	91.9	124.5
1992 Request	178.4	346.0	122.5	156.0
Dollar Change	+21.6	+80.9	+30.6	+31.5
Percent Change	13.8%	30.5%	33.3%	25.3%

Budget calls for overall increase in R&D spending

By Fred W. Weingarten
CRA Staff

Although the administration's fiscal 1993 budget proposal broke no strikingly new ground, it extended and reinforced some important trends in R&D funding that have appeared over the last few years.

Overall, basic research increased 8%, from $13.3 billion to $14.3 billion, continuing a five-year trend of growth in real terms of civilian R&D funding. This increase raises R&D funding from 0.4% to nearly 0.5% of the nation's gross domestic product. R&D growth has been sustained despite a budget agreement that caps growth in total non-defense discretionary spending by the annual inflation rate.

The increase appears to reflect the continuing political judgment and bipartisan consensus between the administration and Congress that R&D support is critical to long-term economic development.

In presenting the budget, D. Allan Bromley, assistant to the president for science and technology, said R&D was "an essential prerequisite to future economic growth, continued national security and improvements in the quality of our lives."

The budget also reflects a continuing shift in R&D funding from defense to civilian agencies. Since 1989, civilian R&D has increased 43%, while defense R&D has gone up only 6%.

The budget proposal continued the trend toward emphasizing interagency presidential initiatives. Funding for the High-Performance Computing and Communications initiative increased 23% to $802.9 million over the fiscal 1992 enacted level. Advanced manufacturing is another R&D area receiving special emphasis in the budget.

Many special initiatives other than HPCC, either directly or indirectly, include some element of computing research. Both the Global Change Research initiative and the new Advanced Manufacturing program have important computing research elements.

On track

The National Science Foundation, in general and in the Computer and Information Science and Engineering (CISE) Directorate, fared especially well in the budget proposal. The administration requested a 17.6% increase for NSF, from $2.55 billion to $3.05 billion. The request keeps the agency on track for doubling its 1988 funding level by 1994.

Much of the increase is for support research for four special initiatives: high-performance computing and communications, global change, advanced materials and processing and advanced manufacturing. And $62 million of the Mathematics and Physical Sciences Directorate funding is earmarked for development and construction of three large-scale research instruments in physics and astronomy.

Budget growth

Table 1 compares the fiscal 1993 request for NSF's directorates to fiscal 1992 estimated funding. CISE funding increased 29%, which was the largest percentage increase among the research directorates. Table 2 breaks down funding among the CISE divisions.

Although the numbers are important, one should not draw too many conclusions from the fine structure of these budgets. Program elements and subfields often are moved around among divisions in response to changes in the field and to keep administrative balance within NSF.

CISE has two related but distinct missions: to support basic computing research and to support the development of the infrastructure and intellectual foundations of computational science. The Advanced Scientific Computing Division, for example, will spend about $66 million to partially support four national supercomputer centers that are open to a broad academic and industrial research community.

The Networking and Communications Research and Infrastructure Division will devote $37 million to support NSFnet, the NSF-funded portion of the interim National Research and Education Network called for in the HPCC initiative and legislation passed by Congress last year.

CISE appears to be benefiting from the four special initiatives. CISE officials report that $59 million of the $61 million increase is due to special initiatives, particularly HPCC and advanced manufacturing. A little less than half of

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Table 1. NSF Directorate Funding in FY 1992 & 1993 (in millions of dollars

Directorate	1992 Estimate	1993 Request	Dollar Change	Percent Change
Research				
Biological Sciences	275	321	+ 46.0	17%
Computer & Information Science & Engineering	211	272	+ 61.0	29%
Engineering	259	313	+ 54.0	21%
Geosciences	404	472	+ 68.0	17%
Mathematical & Physical Science	623	726	+103.0	17%
Social, Behavioral & Economic Science	86	108	+ 22	26%
Total Research Budget	**1,875**	**2,212**	**+337.0**	**18%**
Education	465	479	+ 14.0	3%
Antarctic*	88	163	+ 75.0	85%
Other	112.5	139	+ 26.5	23%
Total NSF Budget	**2,573.5**	**3,027.0**	**+453.5**	**18%**

*Fiscal 1992 includes a $105 million DOD contribution, and the fiscal 1993 figure includes a $14 million contribution.

Fiscal 1993 Budget

Table 2. NSF CISE Program Funding in FY 1991, 1992 & 1993 (in millions of dollars)

Computer & Information Science & Engineering	1991 Actual	1992 Request	1992 Current	1993 Request	Dollar Change	Percent Change
Computer & Computation Research	31.32	37.93	34.84	43.04	+ 8.20	23.5%
Information, Robotics & Intelligent Systems	23.59	29.21	26.98	36.83	+ 9.85	36.3%
Microelectronic Information Processing Systems	18.53	23.50	21.51	30.44	+ 8.93	41.5%
Advanced Scientific Computing	66.51	72.10	69.61	86.71	+17.10	24.6%
Networking & Communications Research & Infrastructure	29.80	42.24	35.49	48.09	+12.60	35.5%
Cross-Disciplinary Activities	19.76	24.52	22.51	27.11	+ 4.60	20.4%
Total	**189.50**	**229.49**	**210.93**	**272.21**	**+61.28**	**29.1%**

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that increase is directed to the infrastructure divisions mentioned above; the rest will go toward the support of research.

Rocky road

Some Washington science policy observers are questioning whether this proposal will survive the rigors of election year politics. Short-term remedies such as tax cuts may well prove to be far more attractive than long-term investments, which further increase budget pressures.

The perception that academic research is overcharging the taxpayer still seems to be growing. This belief could become more widespread and any further revelations could fuel a push to cut R&D budgets. Last year, defense R&D appropriations were cut by a token amount at the last minute as an intentional warning to the research community.

For now, computing research enjoys credibility and a favorable political climate in Congress and the administration. Statements by Bromley and NSF Director Walter Massey indicate that highest funding priority will go to technologies that promise to address social and economic needs.

The problem for the computing research community will be to transform that credibility into appropriations to ensure that computing research progresses toward meeting those expectations.

HPCC program needs input from math science community

Special to CRN

A report by the National Research Council's Commission on Physical Sciences, Mathematics and Applications said the goals of the High-Performance Computing and Communications (HPCC) program cannot be met without the active involvement of the mathematical sciences community.

The report, *Mathematical Foundations of High-Performance Computing and Communications*, outlined 10 HPCC research areas in which mathematical scientists' efforts will be needed. They are numerical algorithms; homogenization methods; dynamic graphics and other visualization methods; queuing theory and network flow algorithms; efficient pattern matching, including dynamic programming; model validation; development of user-friendly software; nonlinear wave propagations; numerical methods in nonlinear dynamical systems; and graph theory and embeddings.

The report also outlined how mathematical sciences can assist the HPCC community with its grand challenge problems. These are significant challenges with solutions that demand computing power far in excess of that available today, it said. These challenges fall in the areas of turbulence research; computational biology; dynamics of cardiac models; global change; material science; semiconductor modeling; geophysical modeling; machine vision; and human–machine communication.

Mathematical sciences already have helped HPCC researchers make strides in hardware, software and algorithms, networks and basic research, the report said. For example, mathematical science research has played a critical role in the development of simulation tools. Mathematical scientists also have been responsible for developing multigrid algorithms for quickly solving elliptic partial differential equations.

In the coming years, mathematical sciences potentially can contribute to advances in all of these areas, the report said. In the hardware area, high-dimensional statistical modeling can help in the process of designing and manufacturing microchips. With circuit geometries becoming increasingly complex, there is an increased need for statistical models that can identify flaws early in wafers and in the chip design process, it said.

In the area of software and algorithms, mathematical sciences can contribute to the process of building random number generators that can run concurrently on 64,000 processors, for example, and produce uncorrelated streams, the report said.

New architectures such as massively parallel machines are increasing the importance of numerical analysis and trade-offs between performance, accuracy and stability of the basic numerical algorithms, it said.

"A most useful advance would be the mathematical abstraction of the general structure of algorithms to display their data flow requirements,'' the report said. "A more ambitious, but still practical advance, would be the creation of higher-level libraries…, which could perform many procedures common to a variety of codes.''

In the network technology area, mathematical scientists can help improve optical fiber technology by using analytical and numerical methods to provide a deeper understanding of basic problems in nonlinear optics. "Algorithmic advances in coding theory and data compression will be needed to handle a wider range of multimedia traffic including data, voice and images,'' the report said. It added that mathematical science can help advance network queuing systems and security.

Finally, mathematical sciences can help to advance basic research and human resources, the report said. Researchers who participate in the HPCC program will need to be well-grounded in mathematical sciences. Education programs at supercomputer centers will accelerate the impact of new mathematical models and algorithms on large-scale computing, it said.

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said Minister of Science William Winegard when questioned about this year's federal budget. "But we're still talking to the provinces to see if we can bring that off."

"Minister Winegard wants the agreement of the provincial ministers," Hutchison said. "There is a meeting of the council of science and technology ministers in late April or May. If we can get some agreement on the idea, we'll move ahead. The next thing will be to issue a RFP."

Regardless of the timetable, high-speed networking seems to have been firmly planted on the political agenda, including the next First Minister's conference with the prime minister and the 10 Canadian province premiers. In a political and economic system still dependent on natural resources, such an achievement is almost startling. "I think it's modest," says Hutchison, "but we're making progress."

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

Los Alamos and Oak Ridge labs designated as HPC research centers

The Department of Energy designated the Los Alamos National Laboratory in New Mexico and the Oak Ridge National Laboratory in Tennessee as High-Performance Computing Research Centers. DOE will provide funding to the labs for four years.

The DOE research centers are part of the administration's initiative to use high-performance computing and communications technologies to strengthen U.S. competitiveness in science and industry.

"I expect these centers to set new standards for collaboration and interdisciplinary research in this field with all its ramifications for our country's economic competitiveness," said Secretary of Energy James D. Watkins.

The centers will use new HPC systems to solve large problems of scientific, economic and environmental importance. Los Alamos will focus on a major global climate modeling problem, in conjunction with Energy's Global Climate Program. The lab will develop new software, networking and storage technologies that will allow scientists to take better advantage of large massively parallel computers. Oak Ridge will focus on modeling pollution in groundwater and designing new materials and alloys. The labs already collaborate in several computational science areas, including global climate modeling and advanced networking.

High costs limit use of HPC systems

Supercomputers have saved U.S. industry billions of dollars, but many industry officials claim that the high cost of the machines and other factors hinder widespread use of the technology, according to a recent General Accounting Office (GAO) report.

Some automobile and aerospace companies have saved millions of dollars by using supercomputers to reduce manufacturing and testing costs. An official at one oil company told GAO that supercomputers increased oil production at his company by as much as $10 billion.

But officials also said barriers prevent them from using supercomputer power more fully. These barriers include the high cost of supercomputers; a lack of applications software; a cultural resistance to shifting from physical experimentation to relying on computational models; and a lack of supercomputing education and training.

The report, *Industry Uses of Supercomputers and High-Speed Networks*, also said industry relies on T1 and T3 networks to transfer large graphics and data files and to access computers worldwide. Industry users need high-speed networks because applications such as videoconferencing require fast transmission; traffic volume is often high; and applications such as database queries require fast response.

Research News

Canadian CS departments, industry collaborating

BY Douglas Powell
Special to CRN

A unique experiment in university–industry collaboration involving a foreign-owned multinational appears to be reaping dividends some two years after its inception. The Toronto-based Center for Advanced Studies (CAS), housed within IBM Canada Laboratory Ltd., represents one of the first serious attempts to combine the talents inherent in Canadian computer science departments with the resources and expertise of a large information technology company.

By making a considerable investment of time and money, IBM is bolstering the on-going development work in the Toronto lab through a series of collaborative research projects, funding graduate students and hosting academics for sabbaticals. In return, university researchers are tackling some difficult problems, expanding their funding base and being exposed to industry research.

The center is a welcome addition to a spectrum of research initiatives in a country faced with some unpleasant fiscal realities. "If you link IBM with Canadian universities, you have the makings of a science and technology powerhouse," said the Federal Minister of Science William Winegard.

Although IBM Canada employs 15,000 people, it is only in the last decade it has become serious about Canadian R&D. The Toronto-based IBM Canada Laboratory has grown from 300 people in 1981 to 1,500 in 1991, which is a compounded annual growth rate of 15%. The dollars spent on homegrown R&D reflect a similar growth, from $34 million in Canadian currency in 1981 to more than $212 million in 1991, making the IBM Canada Laboratory the third largest private sector R&D facility in Canada, behind Bell-Northern Research and Pratt & Whitney.

Bill Etherington, president and chief executive officer of IBM Canada Ltd. since January 1991, said that although his company has contributed more than $60 million in equipment and other support over the past eight years to fund a total of 35 research projects across Canada, "these projects are often very focused on real-world situations, rather than [on] technologies or issues that lie further over the horizon."

At the suggestion of former IBM Canada laboratory director Larry Achtemichuk, and after extensive consultation with the heads of computer science departments from 10 North American institutions, the Toronto laboratory created the Center for Advanced Studies, charged with exploring emerging software technologies. CAS provides a bridge for software technology transfer between North American universities, worldwide research communities, other IBM laboratories and the IBM product development groups in Toronto.

CAS also allows the Toronto group to cross international boundaries and embrace more of the software technology spectrum, from pure, highly theoretical research to applied research. The Toronto lab has global mandates to develop commercial software products across IBM's entire product line, including programming languages; computer-aided software engineering (CASE) tools; relational databases; distributed processing, including repositories and directories; communication protocols; and imaging applications.

According to CAS director Jacob Slonim, the center is driven by the technological expertise resident in the lab. Other IBM labs normally do not have the internal research capabilities to help product developers. CAS now is sponsoring 10 projects in various stages of development and use, including advanced software design technology, object-oriented technology and parallel programming. More than 150 researchers are involved in the projects.

The center has awarded 16 graduate student research fellowships during the past year—10 from Canada and six from the United States. The largest project, the Center of Research for Reliable Distributed Systems (CORDS) is characteristic of the center's approach to research. It involves professors and more than 60 doctorate and master's students from 10 universities, along with IBM researchers from around the world.

CORDS's aim is to develop a prototype environment that will allow the efficient development of distributed tools and applications, based on the philosophy that the logical view of the system must be separated from its physical realization to achieve platform independence. The environment will incorporate many changes:

- a new process model, incorporated into existing languages, embodied in a new high-level language, and demanding new implementation techniques;
- network management;
- modeling and analysis of distributed applications;
- distributed database and directory services; and
- distributed debugging and other programming tools.

CORDS is designed to leverage the lab's AIX CASE mission, as well as the strategic application enabling mission. "We are in the business of developing commercially successful software products for the global marketplace," Achtemichuk said. He is now a vice president with parent IBM Corp. "We are expanding our activities to include not only product development and ongoing application of advanced technology, but also adding research into selected emerging software technologies."

The Center for Advanced Studies provides a bridge for software technology transfer between North American universities, worldwide research communities, other IBM laboratories and the IBM product development groups in Toronto.

The focus on software not only fits the global product mandates of the Toronto labs, it draws on recognized Canadian strengths. This was recently confirmed in a much ballyhooed study of Canadian competitiveness by Harvard business guru Michael Porter. Citing the benefits of industrial clustering, Porter highlighted the software development industry in Canada as an existing strength.

In fact, of the $5 billion Canadian industry spent on all R&D in 1990, software development accounted for more than 24%, or $1.2 billion. John Armstrong, vice president of science and technology at IBM Corp., said human resources is one of the real Canadian strengths in computer science, a crucial factor when determining what laboratory within IBM is awarded a global product mandate. "There are a lot of good universities, and lots of good people in Canada," he said.

Slonim said, "One of the key objectives of CAS is to match the very best computer scientists in IBM with the very best in Canadian universities. It is my task to develop collaborative research projects that address the fundamental technological issues affecting the future of our company.

"Not only have we been successful in attracting world-class academics with excellent scientific credentials, but we have been able to foster their full collaboration with each other and with industry. This accomplishment should not be underestimated, as it represents a significant change in behavior for many university researchers," Slonim said.

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

U.S. leads Japan, Europe in miniaturization technology

Special to CRN

A report by the Office of Technology Assessment said the United States leads Japan and Europe in miniaturization technology R&D, but the lead is less substantial than it has been in the past.

In general, U.S. research in miniaturization technology surpasses programs in Japan and Europe, although there are a few research areas in which the United States lags behind other countries, the report said. OTA said there is a danger that U.S. companies will not put the new technologies into use as quickly as other countries, especially when the technologies are driven by products or markets dominated by another nation.

"Although U.S. [R&D] is still sound, U.S. industry has a mixed record in the implementation of miniaturization technology," the report said. "Many miniaturization technologies that are crucial to the success of consumer electronics, for example, were embraced by Japanese industry more quickly."

The report, *Miniaturization Technologies*, said progress in the area of miniaturization shows no signs of slowing in the coming decade. By the year 2000, the miniaturization process will be able to produce memory chips with 1 billion transistors and the capacity to store 1 billion bits of information, OTA reported. But because of the high cost of new fabrication equipment and processes, chip fabrication plants will cost more than $1 billion as opposed to current plants that cost hundreds of millions of dollars.

The report said the United States leads the world in research on smaller transistors because of its strength in the areas of computer modeling and basic sciences. But because the Japanese traditionally have been more concerned with packing electronics into portable consumer products, they have been the leaders in using small transistors commercially, it said. OTA found that U.S. and Japanese industry annually spend about the same amount on semiconductor R&D: $3.7 billion in the United States and $4 billion in Japan.

In addition, the technology used for semiconductor manufacturing can be applied to other fields such as sensor fabrication. For example, integrated circuit manufacturing techniques are used to create biosensors and chemical sensors that will be used for food processing and medical applications. By using these manufacturing techniques, scientists can create cheaper and more ubiquitous sensors, the report said.

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Research News

The history of MCC's innovative software program

BY Laszlo A. Belady

Last October 1991, fragments of the Microelectronics and Computer Technology Corp.'s Software Technology Program (STP) were distributed into the reorganized hierarchy of MCC, putting an end to perhaps the most coherent and innovative of all the major software technology efforts. Belady led the program for all but the last five months. This article summarizes the history of the program and speculates about the reasons for its relatively early and unsatisfactory termination and is an edited version of an article published in *American Programmer*, Vol. 5, No. 1, January 1992, pp. 10-15. Copyright 1992 by Laszlo A. Belady.[1]

The first year: focusing on the mission

On Sept. 10, 1984, the Software Technology Program had a secretary; five liaisons representing Digital Equipment Corp., Control Data Corp., Rockwell, RCA and Harris Corp.; and a researcher whom the program's director hired one day before he arrived.

STP was one of seven programs[2] created by the founding fathers of the MCC consortium, which was started under the direction of retired Adm. Bobby Ray Inman, who served as president. The spirit in the consortium was high, and everybody—from the Austin, TX, community to the 18 shareholders—was upbeat and friendly.

After a meeting with shareholder technical representatives[3] on Sept. 21, it was clear the main problems with industrial programming lie in the development and maintenance of large, software-intensive systems. Because MCC management and the participating companies offered little, and sometimes contradictory, advice—except for something like "fix the software problem"—it was obvious that MCC, and in particular STP, would have to direct the programs.

This was quite unusual for someone like me who came from IBM where new ideas or directions must be presented to, and approved by, numerous groups and experts before anything can happen. Inman's inspired leadership strategy, which delegated significant decisions to the program directors and held bureaucracy to a delightful minimum, was quite refreshing.

This freedom of choice, offered by both "customer" and MCC management, was a mixed blessing. Although we received an immense amount of advice from academia and elsewhere as to what to do for software research, we realized we could not do everything and should not mimic an academic computer science department.

We needed to rely on good academic research, such as in theoretical areas for which the university environment is more nurturing, but we had to exploit our advantages of having more intimate involvement with industrial software developers, being capable of establishing a set of coherent projects, sharing a vision and feeding on each other's results.

This realization resulted in STP's sustained belief in problem-driven research focused on an emerging and increasingly important area. By the end of 1984, our strategy was that given our mission to improve programming productivity and the quality of the resulting product, we would attack the large-scale or organizational programming process and leave the problem of small programs written by individuals or by informal teams for others.

To focus further, we selected requirements formation and systems design as the upstream phases of the standard software process.[4] These phases ultimately lead to more formal specifications. The specifications later would help programmers construct machine interpretable programs. We started talking more about design, specifically early systems design, which we thought included decisions about hardware.

The first four groups we formed at the end of 1985 were design environments, design information, design interface and design process. We organized a workshop in Austin on interdisciplinary design in 1985. This meeting was the first of its kind. We invited software researchers and practitioners as attendees and design theorists and chief designers of complex (but not necessarily software) projects as speakers. Another STP innovation was a computer-supported cooperative work sequence of conferences.

We thought computer science was too compartmentalized. For instance, software engineering and distributed systems were studied by researchers separately and without much interaction. We wanted to be in the intersection of these disciplines, and because we thought distributed systems would be more challenging to design than serial ones, we launched an effort in this area.

Shared vision

We forged a lasting focus[5] based on a shared vision. This vision helped us develop a problem-driven approach; select research areas; develop an openness for incorporating solutions, even if they came from the outside; and realize that software design transcends pure programming and technology developed for software design support may aid in the design of other complex systems.

The issue of building our team, which was one of the few assets of a research organization such as STP, deserves more attention. Unfortunately, we yielded to pressure from shareholders and MCC management to build up rapidly. This resulted in somewhat lower quality than a slower staffing process might have and it made later team building more difficult. The newcomers were strangers; they were looking for something meaningful to do because no existing projects fit the experience of the typical researcher we hired.

There was another sign of early impatience. In our sixth month, I was courageous enough to call the first program technical advisory board meeting of our shareholder representatives. In the true tradition of short-term thinking, and in a rather massive misunderstanding of our research vision, one delegate stood up and asked, "Where are the deliverables?" We had a hard time answering that question.

The middle years: taking shape

After about two years, the major effects started taking shape. The method with which we achieved this is still the best. We moved deliberately, but pushed ahead early with some rough ideas. If you get your hands dirty, you learn from your experiences and find the best way. We had only one shared mantra, and we called it "Leonardo."

The essence of our method was that we had to perform good industrial research that moved us toward a comprehensive software design environment called Leonardo. This environment would bring together a variety of programmers, users, customers and managers via a network of interactive workstations.

We organized into four groups, and spontaneous activities based on one or more person's ideas would emerge and eventually become a project, as long as the idea was judged as consistent with Leonardo.

Several projects emerged. We started building an environment for LISP-based programming called DELI. Aided by my 10-year contact with Professor H. Rittel[6] of the University of California, Berkeley, we imported the issue-based information system concept and merged it with Hypertext-oriented graphics, ending up with our own gIBIS technology. We designed and built a groupware laboratory, and in 1986 organized the first computer-supported cooperative work workshop. We also started work in reusing design, not just code segments. And our Petri net-based language effort gave us the chance to offer a graphic aid to improve distributed systems design.

Communication was a continual problem. The entire staff did not buy into the Leonardo concept, and many researchers tended to continue their old line of research. Although program management put lots of energy into keeping all efforts well-aligned and synergistic with each other, some individuals spent too little time trying to understand and discuss STP research beyond their own efforts.

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The format of an ad must conform to the following: (1) the first line must contain the name of the university or organization and will be printed in bold, (2) the second line must contain the name of the department or unit and will be printed in italics and (3) the body of the ad should be in broken into paragraphs. The words in the first two lines are included in the total word count for the ad. Any headings or text requested in all uppercase will be set in bold and counted as two words.

The rate is $1 per word (U.S. currency). A check or money order *(please do not send cash)* must accompany the ad copy. Purchase orders are acceptable. All CRA members receive at least 200 free words per dues year.

Display ads cost $30 per column inch. The ad must be submitted in camera ready, offset (positives or negatives) or mechanical form.

Computing Research News is published five times per year in January, March, May, September and November. Professional Opportunities ads with application deadlines falling within the month of publication will not be accepted. (An ad published in the May issue must show an application deadline of June 1 or later.) Advertising copy must be received at least one month before publication. (The deadline for the May issue is April 1.)

Bowie State University

Natural Science/Mathematics/ Computer Science Department

Applications are invited for a faculty position at the assistant or associate level in the computer science program at Bowie State University (BSU) to begin this fall. A Ph.D. in computer science or computer engineering is required. Candidates specializing in parallel or distributed computing, computer graphics or computer architecture are preferred. Commitment to excellence in teaching and the ability to communicate effectively are essential. Appointee is to participate in a National Science Foundation-funded institutional infrastructure grant. Rank and salary are negotiable.

The university enrolls more than 4,200 students and offers bachelor's and master's of science degrees in computer science. BSU is located in the Baltimore–Washington corridor and is near many government agencies and research laboratories, including NASA, NSF, National Security Agency and National Institute of Standards and Technology.

Applications will be accepted until April 1. Send vita, transcript and three letters of recommendation to Professor Nagi Wakim, Computer Science, Bowie State University, Bowie, MD 20715.

Applicants must be U.S. citizens or permanent residents. BSU is an equal opportunity, affirmative action employer. Women and minorities are encouraged to apply.

State University of New York at Albany

Computer Science Department

The University at Albany computer science department invites applications for a tenure-track position at the assistant professor level commencing this fall. Candidates must have a doctorate in computer science or a related field. The department has a strong interest in recruiting a faculty member whose research area is in systems or an experimental area. Candidates whose research interests can contribute to other research efforts both on and off campus are especially desired. However, applications from candidates in any area are welcome. Other desirable qualifications are a commitment to teaching, as well as the ability to teach systems and software engineering courses.

The department has 15 full-time faculty members and maintains active research programs in many areas. Bachelor's and master's of science and doctoral degrees are offered. The tenured faculty are D.N. Arden, P.A. Bloniarz, S.D. Chaiken, H.B. Hunt, D. Kapur, N.V. Murray, S.S. Ravi, D.J. Rosenkrantz, R.E. Stearns and D.E. Willard.

The university is in a metropolitan area of 750,000 people that offers many cultural, recreational and scientific facilities. Albany is within easy driving distance of New York, Boston and Montreal.

Applications should be sent to Professor R.E. Stearns, search committee chair, computer science department, University at Albany, 1400 Washington Ave., Albany, NY 12222. E-mail: res@cs.albany.edu.

The University at Albany is an equal opportunity, affirmative action employer. Applications from women, minorities, handicapped persons and special disabled or Vietnam-era veterans are especially welcome.

University of Florida

Department of Computer and Information Sciences

The computer and information sciences department invites applications for tenured or tenure-track positions at senior and junior levels in the area of software engineering. One of the positions will have the assignment as the director of the Software Engineering Research Center in the NSF Industry/University Cooperative Research Centers Program.

Applicants must possess a doctoral degree in computer science or equivalent and show a strong record and commitment to teaching and research in software engineering and related areas. Some administrative and/or industrial experience for senior level candidates is desirable. The positions are available starting in the 1992–1993 academic year or earlier.

Applicants should send their resumes and the names and addresses of four references to Professor Randy Chow, chair, faculty search and screening committee, computer and information sciences department, 301 CSE, University of Florida, Gainesville, FL 32611-2024. Tel. 904-392-1200; E-mail: chow@cis.ufl.edu.

The closing date is March 1 or until the positions are filled. The University of Florida is an equal opportunity, affirmative action employer. This faculty search will be conducted in compliance with Florida's Government in the Sunshine Law.

University of Illinois at Urbana-Champaign

Department of Computer Science

The department of computer science at the University of Illinois, Urbana-Champaign, anticipates possible tenure or tenure-track appointments in several disciplines. Applicants must have outstanding academic credentials and an ability to teach effectively at both the graduate and undergraduate levels. Successful candidates will be expected to initiate and carry out independent research and perform academic duties associated with our bachelor's and master's of science and doctoral programs.

To ensure full consideration, applications must be received by April 15, although the search will continue until positions have been filled. A Ph.D. degree or imminent completion of a Ph.D. is required. Salary is open and based on qualifications. Starting dates are Aug. 21, 1992, or Jan. 6, 1993. Send resume and the names of three references to Duncan H. Lawrie, head, department of computer science, 1304 W. Springfield Ave., Urbana, IL 61801. Tel. 217-333-6454.

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

University of Tennessee

Department of Computer Science

The department of computer science at the University of Tennessee invites applications for tenure-track positions at the rank of professor beginning this fall. 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.

Tenure-track positions for associate and assistant professors also are open. Applicants for associate professor should have a strong research record, preferably in the above-named areas. Experience directing doctoral students is desirable. Applicants for assistant professor should have a strong interest in research, preferably in the above-named areas. Applicants for all positions should have a doctoral degree in computer science or a related area.

Fully networked departmental Sun, IBM and DEC workstations abound for students and faculty. The department also has acquired a Thinking Machines CM-5. The department and the Mathematical Sciences Section of the Oak Ridge National Laboratory jointly operate the Advanced Computing Laboratory, which includes a

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fully networked Intel iPSC/860 with 128 processors, an iPSC/2 with 64 processors, two Sequent Balances, a Sequent Symmetry, a Stardent Titan with four processors, a Cognent, an NCube, a Kendall Square Research machine with 32 processors and various file servers. Oak Ridge National Laboratory is acquiring an Intel Paragon.

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. The university operates an IBM 3090 and large DEC VAX cluster.

Please respond by E-mail to straight@cs.utk.edu or mail responses to the department of computer science, 107 Ayres Hall, University of Tennessee, Knoxville TN 37996-1301.

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

University of Oregon

Department of Computer and Information Science

The department of computer and information science invites applications for a senior faculty position created by a new state Centers of Excellence award. We are seeking a person who will be an active leader in the department, willing to serve one or more terms as department head and play a key role in relations to the computer industry.

Applicants should have a Ph.D. in computer science or related field and a distinguished record of teaching and research in the area of parallel processing, including parallel architectures, languages and performance modeling, or human-computer interaction, including computer graphics and scientific visualization.

Our department has 14 other faculty positions, including one other new position for which we are currently recruiting, about 20 Ph.D. students, 50 master's of science students and 150 bachelor's of science students.

We have strong research programs in parallel and distributed systems, computer graphics, user interfaces, programming languages, software engineering, artificial intelligence and theoretical computer science, and we have active interdisciplinary ties with other on-campus groups in the fields of cognitive science, neuroscience, economics, biology, physics and mathematics. We offer a modern computing environment (a MasPar MP-1100, two Sequent Symmetry multiprocessors and dozens of Sun and HP workstations) housed in a new computer science building.

Review of applications will begin April 15 and continue until the position is filled. The position is available in September, with a target date to fill the position by January 1993. Qualified applicants should send a curriculum vita and the names of at least three references to Professor John Conery, faculty search committee, department of computer and information science, University of Oregon, Eugene, OR, 97403-1202. Tel. 503-346-3973; E-mail: conery@cs.uoregon.edu.

We especially encourage applications from women and minorities. The University of Oregon is an equal opportunity, affirmative action employer committed to cultural diversity.

The University of Chicago

Department of Computer Science

The department of computer science at the University of Chicago has junior and senior positions available. The university prefers candidates with expertise in an area of experimental computer science, such as programming languages or distributed systems, but it will consider exceptionally strong applicants from any area.

Send curriculum vita and three letters of reference to Professor Janos Simon, chair, department of computer science, University of Chicago, 1100 E. 58th St., Chicago, IL 60637. Inquiries can be directed to chair@cs.uchicago.edu.

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

University of Pennsylvania

Department of Computer and Information Science

Applications are invited for an instructorship position beginning in July in the University of Pennsylvania department of computer and information science. Responsibilities include preparing, teaching, overseeing and coordinating introductory courses in the undergraduate program. The teaching load is the equivalent of three courses per semester, adjusted for time spent on laboratory and curriculum development. Contract period is two years, with the possibility of a one-year renewal.

Candidates should have at least a master's degree in computer science, teaching experience at the undergraduate level and familiarity with C, Pascal and Scheme (or Lisp). Familiarity with ML would be useful, but not essential. Candidates should be able to demonstrate ability and strong interest in teaching undergraduates.

Send resumes and the names of three references to Dr. Jean Gallier, chair of faculty recruiting, department of computer and information science, University of Pennsylvania, Philadelphia, PA 19104-6389.

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

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"Integrating sensors with electronics promises to increase the versatility of sensors for consumer, medicine, automotive, aerospace and robotics markets," the report said.

The report also said scientists will need to better understand the materials and surface interactions involved in miniaturization if they are to advance the technology further in the coming years. They will need to gain a greater comprehension of how to bond molecules to surfaces and the mechanical and surface properties of materials such as silicon. Gains made in these areas will help resolve problems in quantum electronics and molecular computing, OTA said.

OTA prepared the report at the request of members of the House Committee on Science, Space and Technology. The report costs $3.25 and can be ordered from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9325. The GPO stock number of the report is 052-003-01267-7.

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Over the years, the original project composition changed, thanks to our dynamic activity mechanism. By the end of the 1980s, we had gIBIS, a graphic distributed system building tool called VERDI, a new effort in human coordination technology based on our distributed system experience, a design recovery and reverse engineering[7] tool built upon our reuse work, a new effort in the practical use of formal methods and, by transfer from another program, a logic-based database and programming language called LDL.

The Leonardo concept faded away. Because of the technology transfer problem, we had to give up building even an incomplete environment. The DELI prototype was transferred elsewhere for commercialization, although we kept experimenting with systems integration technology.

The final years: funding problems

The last two years were characterized by a reduction of funds. While STP peaked in 1986 with 10 shareholders (Bellcore and Motorola joined the original eight), only six remained in 1989. We lost RCA and Sperry because of mergers and acquisitions, while Lockheed and Harris lost patience with the sluggish absorption of technology.

The remaining shareholders changed their funding policies in different ways. This decreased the budget available for the program. By the last two years we understood and practiced technology transfer much better. It is sad the founding fathers did not foresee the great effort that would be needed to work with shareholder organizations and to prepare for the absorption of novel technology.

By the time this need was clear, the money was gone. The six core shareholders, or at least their regular visiting representatives, were on our side. They said they were satisfied with the program's direction and approach, and they encouraged us to go after other companies more aggressively.

This was a new task for the entire staff. We did not anticipate the huge amount of time, travel and effort this marketing venture would require. It became a continuous crescendo, culminating in a sizable professional marketing staff and a huge load on all the senior people. Yet it was not successful. Most prospects believed they should be able to join for just a few thousand dollars. They compared us to universities with regard to funding.

When we created individually supported projects out of the program, the result was more complex marketing and meager results. Why did STP, along with MCC's CAD-VLSI program, have such a short life and so little direct impact on the software industry?

The answer is complex, and this article offers a glimpse at some of the pieces, including an underestimation of the time scale of a new research effort, which led to shareholder impatience; an insufficient budget for the cost of absorbing the technology back at the participating companies, which resulted in a gap between research results and finished software tools; delayed discovery of the marketing necessary to secure sufficient funding; shareholder company mergers and acquisitions; and other changes in management that placed decision makers unfriendly to MCC and the concept of consortia in general in charge. Other reasons may have contributed to the failure.

• STP was embedded into an essentially microelectronics research environment. On the surface, this looked very progressive and promised interdisciplinary work, but in reality it provided hardware-flavored managers who did not understand or sympathize with software.

• During the second half of the 1980s, the CASE industry started flexing its muscles, offering packaged and turnkey tools to support selected phases of the software process. These tools were attractive because they were quite powerful and at a level difficult to reach with research-only funding we received. These tools competed well with STP's output.

• Many participants had their own research or their own advanced development groups in software technology. These people were not friendly to STP. Instead, they lobbied to channel funds intended for MCC into their own organizations. This occurred at a time when funding for any longer-term research was dwindling.

• As a result of the "what have you done for me this week" atmosphere of the late 1980s, we lost many good people who went to larger, more stable organizations.

• We did not create a sufficient network of university contacts to tap academic talent via joint efforts and intensive exchange of ideas. Although we always believed this was important, we were not able to do this.

• We could not build a bridge to our real customers. We did not even find out who they were because our participants were lost in a maze of organizational bureaucracies.

Shareholder technical committee members were on our side, but their influence and experience rarely was on a par with that of a powerful software development line executive. We occasionally did find such a champion, and we were well-respected and had a good relationship with the respective company.

Ambitious project

Given the lack of patience for providing funding and time, perhaps we were too ambitious. Instead of attacking the design of complex systems, which is a huge and persistent problem, perhaps we should have joined others and continued research along established lines of technologies, such as programming languages, object orientation and testing.

Notes

1. The Microelectronics and Computer Technology Corp. was chartered in 1983 and based in Austin, TX. An article by Ed Yourdon in the May 1989 issue of *American Programmer* describes the organization.

2. Four of the seven programs—parallel processing, database, human interface and artificial intelligence—collectively were referred to as advanced computer architecture (ACA) and later were merged into a single program called advanced computing technology (ACT), resulting in only four major programs in MCC.

3. Each shareholder was free to support any number of programs, but had to

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Conferences

Snowbird Conference '92 ♦ July 12–14 ♦ Snowbird, Utah

Preliminary Agenda

Sunday, July 12

Registration
3:00PM - 7:30PM

Welcome Reception
6:00PM -7:30PM

Dinner and State of the CRA Address
7:30PM - 9:30PM
John Rice, chair of the CRA board of directors, will update attendees on CRA activities.
Fred W. Weingarten, CRA's executive director, will offer some brief insights into how science and technology policy is affecting the presidential election.

Monday, July 13

Morning

Breakfast
7:00AM – 8:30AM

Keynote Address
8:30AM – 10:00AM
The Changing Face of Industry and Academia Relations
Increasingly, policymakers at both the state and federal levels are expecting academic research and graduate education to deal with this country's economic and social needs, as well as contribute toward the development of new industrial products and services.

To meet these expectations, industry and academic researchers are being forced to forge closer relationships.

A leading senior computer industry executive and a noted academic leader will address the issues, problems and opportunities arising from these cooperative efforts.

Morning Break
10:00AM – 10:30AM

Panel Discussion
10:30AM – 12 NOON
How Can Universities and Academia Work Better Together?
A panel of industrial computing research managers and academic department heads will lead a discussion of industry and academic relationships prompted by the Keynote Address.

The discussion will highlight the problems and opportunities created by this closer industry and academia relationship. The panel will focus on the ways to make the relationship work.

Audience participation is key.

Afternoon

Luncheon and Address
12:00 NOON – 2:00PM
A. Nico Haberman, the assistant director of the National Science Foundation's Computer and Information Engineering Directorate, will discuss modern trends in federal science policy.

Panel Discussion
2:00PM – 3:30PM
Human Resources: Where are We Now?
• Ph.D. production in computer science and engineering is up once again this year, topping 1,000 for the first time.

Are there enough jobs for Ph.D. recipients? Should there be? Should we rethink our assumptions about what Ph.D.s in these fields do or should do? Is the education they get appropriate for the jobs they seek?

Experts will debate these issues.

• Aggregate numbers are not the only important human resource issue. Find out what is being done to increase the participation of women and minorities in computing research.

Afternoon Break
3:30PM – 4:00PM

Session
4:00PM – 5:30PM
What's New at the Computer Science and Telecommunications Board?
Juris Hartmanis, study committee chair, and Herb Lin, study director, will discuss the CSTB study on the scope and direction of computer science and engineering.

Marjory Blumenthal, CSTB's executive director, will report on the companion project on human resource issues in the field. CSTB also has been active in many other areas since the last Snowbird update.

Evening

Dinner and address
6:30PM – 8:30PM
To be announced

Tuesday, July 14

Morning

Breakfast
7:00AM – 8:30AM

Session
8:30AM – 10:00AM
New Directions in Computer Science and Engineering Research
Can we simply and accurately communicate computing research results to lay people?

Noted computing research specialists will report on major new research problems and findings in their laboratories, with emphasis on how to communicate such findings to non-specialists.

Morning Break
10:00AM – 10:30AM

Session
10:30AM – 12:00 NOON
How Seriously are Politics and Tight Budgets Affecting Computing Research?
Computing is a politically popular issue. This year's presidential election is increasing the attention placed on this issue.

However, with the United States still in recession and the government unable to control the deficit, federal budgets are very tight.

Program officials from the science agencies will discuss their views of the political environment and implications for research support programs.

Afternoon

Luncheon and Address
12:00 NOON – 1:30PM
Herbert Edelsbrunner, a computer science professor at the University of Illinois, Champaign-Urbana, and a winner of the Alan T. Waterman Award, will discuss recent advances in computational geometry.

Workshops
1:30PM – 3:00PM and 3:30PM – 5:00PM
Topics to be announced

If you would like to receive registration information, please contact CRA at 1625 Massachusetts Ave. NW, Suite 110, Washington, DC 20036-2212.
E-mail: Kimberly@cs.umd.edu.

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support at least one. By the end of 1984, CDC, DEC, Harris, Lockheed, RCA, Rockwell, Sperry and NCR participated in STP.

4. Although the author had been quite active since the early 1970s in making software maintenance an accepted research topic, in STP we chose not to go into this area directly. STP kept the focus sharp and hoped that well-designed systems would be more maintainable. This rule was slightly violated five years later.

5. It is interesting that the chosen focus (upstream of large-scale systems development) remained unchallenged during the entire life of STP.

6. Rittel also is the originator of "wicked problems."

7. This was clearly in support of maintenance.

Laszlo A. Belady is the chair and director of the laboratory of Mitsubishi Electric Research Laboratories Inc. (MERL), a recently established computer science center in Cambridge, MA.

Computing pioneer Grace Hopper dies

Grace Murry Hopper, a retired rear admiral and computer pioneer; died in January after a heart attack. She was 85.

Shortly before she died, Hopper was awarded the National Medal of Technology. She was cited for "her pioneering accomplishments in the development of computer programming languages that simplified computer technology and opened the door to a significantly large universe of users."

Hopper was a co-inventor of the Cobol programming language.

Hopper graduated from Vassar College with degrees in mathematics and physics. She received master's and doctoral degrees in mathematics from Yale University.

She permanently retired from the Navy in 1986 and then worked as a senior consultant to Digital Equipment Corp.