RESEARCH ARTICLE | SEPTEMBER 01 1994

NCSA's Director Champions Broad Access to Supercomputers FREE

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Comput. Phys. 8, 496–497 (1994)
https://doi.org/10.1063/1.4823325

An Interview with

Larry Smarr

NCSA's Director Champions Broad Access to Supercomputers

Numerical computing is experiencing a second Golden Age, comparable to the first in the 1960s, a time when the National Science Foundation (NSF) helped build state-of-the art computer centers at universities and when universities could purchase IBM's fastest mainframes at major discounts.

Larry Smarr, director of the National Center for Supercomputing Applications (NCSA) in Champaign, Illinois, has played a major role in the re-creation of this Golden Age over the past decade—as an advocate for access to supercomputers, as well as a researcher and administrator.

If Smarr, also a professor of physics at the University of Illinois at Urbana-Champaign, had not listened to his father, the current status of academic supercomputing might have been very different.

"I started using computers when I went off to college at the University of Missouri in 1966," Smarr told *Computers in Physics*. His father, a small businessman, believed that computers would be important in the future and encouraged his son to look into them.

"Being a dutiful son, I began to take computer courses," said Smarr, who oversees one of four national supercomputing centers funded by the NSF. "By the time I was a senior I had written my first six-foot-long program—solving the Schrödinger equation for neutron-nucleon scattering using complex optical potential. So computers and physics were all intermixed, as far as I was concerned."

Smarr did his doctoral work at the University of Texas with Bryce DeWitt, an expert on quantum gravity. DeWitt had suggested in 1957, at one of the early meetings on general relativity following Einstein's death, that digital computers could be used to solve the two-body problem in general relativity—the collision of two black holes.

In 1975, almost 20 years later, Smarr was a graduate student of DeWitt's, doing his thesis on general relativity, with the collision of two black holes as a numerical illustration. Computers had become increasingly powerful by then, but still not capable of solving this problem.

"As physicists, we talk about the wonderful nonlinear dynamics of general relativity," the NCSA director said. "We imagine these black holes coming, warping space and time; the space is wobbling back and forth, shucking off gravitational waves that head out at the speed of light; and the [event] horizons capture each other." This all represents a tremendous amount of nonlinear dynamics that cannot be dealt with analytically, he said.

"This really meant that if you wanted to get at the core of Einstein's equations—to get at the guts of what was new and interesting beyond Newtonian theory—you had to invent a new way of doing it," Smarr said. "And that way was to use discrete mathematics to replace the continuum of space and time with a discrete space/time lattice, and then use a supercomputer to solve the system there."

At about this same time in the mid-1970s, Kenneth Wilson and other quantum theorists were finding that the solution of quantum chromodynamics (QCD), another important nonlinear problem, would require use of a discrete space/time lattice. The era's supercomputers were getting powerful enough to begin to attack these "gold-ring" problems. However, the mathematical formalism for solving these problems numerically did not yet exist.

Solving these problems required supercomputers, but, at the time, the Department of Energy's nuclear-weapons laboratories were the only places in the United States at which researchers had access to supercomputers. DeWitt encouraged a dubious Smarr to get the needed top-secret clearance to spend summers at Lawrence Livermore National Laboratory in California, where he worked 100 hours a week to cram a year's worth of scientific work into a few weeks.

"So I got a security clearance, went out to Livermore, and worked with people like Ken Epply, James Wilson, and Jim LeBlanc," Smarr said. "And we showed that you could solve the two-black-hole collision, as well as colliding neutron stars and collapsing supernovas, and so on."

In the early 1980s, visits to the Max-Planck Institute for Physics and Astrophysics in Munich afforded Smarr a vision of something different. The institute had an American-built supercomputer (a Cray 1) that was available openly to researchers. His tales of having to go to Germany to get access to an American-made supercomputer became one of the most powerful weapons in Smarr's later fight to improve academic computing.

Outside the nuclear-weapons laboratories, between about 1970 and 1985, numerical computing suffered from "benign neglect" from the federal government, Smarr said. "In the period from 1975 to 1977, there were four CDC [Control Data Corporation] 7600s at Livermore, but no American university—not one!—ever got a 7600."

According to Smarr, this neglect warped the course of American physics for 15 years. Starved of numerical-computing capability, university faculty turned away from complex science problems to work on theoretical problems, or those amenable to analytic methods.

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During this period, computational science was kept alive by users of Digital Equipment Corporation's VAX computers. Unfortunately, researchers had to simplify their problems to match the capabilities of the VAX line. Today, Smarr noted, researchers have a wide choice of machines on which to run large numeric calculations.

"The supercomputing centers and the NSFnet greatly democratized access, so that anyone in 200 universities who has a good idea could carry it out because all the supercomputer time is allocated by peer review, like telescope-observing time," Smarr said. This opening up of access is important because good ideas are not found only at those few universities able to afford their own machines, he said.

By the early 1980s, NSF had recognized the problem of lack of access to state-of-the-art computing technology, and it commissioned several blue-ribbon panels. These groups recommended that national centers be established to make access more available. The threat of Japanese entry into the supercomputer business added impetus to the recommendations, Smarr noted.

"At the same time, people like Ken Wilson and myself were going around pounding on the media, Congress, and so forth, making a national call for a program like this."

Another of Smarr's contributions to this campaign was a widely circulated but unpublished "white paper," which included statements from 60 faculty in 15 departments citing important numerical work that they could not do because of lack of access to supercomputers.

Smarr, a believer in "proposal push," wrote with colleagues at Illinois an unsolicited $43 million proposal for a supercomputing center. Because the NSF had no program at that time to support academic supercomputing, the Illinois group sent its proposal directly to NSF's director.

Congress acted in the spring of 1984 to pass legislation calling for a series of national supercomputing centers and a national research network. This led to NSF's creating its current program in 1985 and conducting a national competition to locate the centers.

Illinois was invited to compete for one of the centers, and the National Center for Supercomputing Applications was born.

"The most difficult thing about making NCSA successful has been simply learning to do management of a large-scale scientific project," Smarr told *Computers in Physics*. "Anybody can go out and issue a $20 million purchase order for a supercomputer, but making sure that you are able to handle 24-hour access, seven days a week, to the national community—while setting up training programs, consulting programs, doing software development, and having visitor programs—is just a huge task to start from nothing."

The four NSF centers (linked as of this October by a 155-Mbits/s backbone—nearly 3000 times as fast as the original 56-kbits/s NSFnet backbone) are sometimes thought of as forming one distributed center, a national Metacenter. According to Smarr, the Metacenter is not a single management unit, but rather a conceptual framework in which a national strategy can be carried out. [*For more on the Metacenter, see p. 540 — Ed.*]

Perhaps the most famous product of NCSA has been the Mosaic software for browsing the World Wide Web [see CIP 8:3 (1994), pp. 249 and 298], itself a product of the physics community (the Web was created at the research facility CERN in Geneva, Switzerland). Smarr noted that software development has been part of NCSA's mission from the beginning, and that the center made a similar, though smaller, splash with the release of NCSA Telnet in 1986.

Mosaic, which is currently being commercialized, will make a major change in how physicists communicate, Smarr said. He noted that the American Physical Society is considering making its journals available in Mosaic format. "Before long, you should be able to get the journals online, with the illustrations and equations."

Even precollege science education is being influenced by the supercomputing centers. Physics laboratories are even scarcer than physics teachers in grades K-12, according to Smarr. But the supercomputing centers may help to change that.

"We have experiments now in chemistry and in galaxy collisions where the client is simple to use—like a video game—while the back-end sits on a supercomputer across the network," he said. "It seems to be interactive, even though you couldn't have the physics equations solved rapidly enough on a workstation or personal computer. But you can on a supercomputer with a workstation as an easy-to-use front-end."

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