The Soul Of the Ultimate Machine

By JOHN MARKOFF

LA JOLLA, Calif.

THE Silicon Valley crowd that assembled last week in a San Francisco airport hotel had come to hear about mobile electronic commerce, a most immediate concern for people who spend many of their waking hours thinking about whether their latest e-business solution will merit venture capital dollars.

They learned about something very different.

Instead of talking about buying Barbies online, the astrophysicist Larry Smarr came to tell them about what he calls "the emerging planetary supercomputer." The Internet, he explained, is evolving into a single vast computer fashioned out of billions of interconnected processors. Then he went another step: "The real question, from a software point of view, is: Will it become self-aware?"

To Dr. Smarr, the idea of a thinking machine that might emerge spontaneously from billions of interconnected large and small computers isn't harebrained at all. He said he was simply extrapolating a series of significant trends that, to him, are remarkably obvious. And when it comes to extrapolating trends and forecasting technological revolutions, Dr. Smarr is worth listening to.

Fifteen years ago — prehistory in Internet terms — Dr. Smarr persuaded the federal government to establish supercomputer centers for civilian research. That bit of brass led to the birth of technologies like the Web browser and advanced computer-graphics programs that allow scientists to see how hurricanes work and let moviegoers stare dinosaurs in the eye. Along the way, he also helped expand a network of computers that were owned by military contractors, corporations and universities into what is now called the Internet.

Now Dr. Smarr has persuaded Gov. Gray Davis of California to put him in charge of the California Institute of Telecommunications and Information Technology, a new state-financed research academy in this seaside San Diego suburb, with the goal of envisioning the future — and making it happen. Governor Davis announced his decision to authorize Dr. Smarr's institute and two others on Thursday.

And what Dr. Smarr sees is this: the rapid emergence of a much more extensive cyberspace that will essentially mirror the physical world. He imagines bridges that are covered with a fabric of computerized sensors that will automatically tell engineers where earthquake damage has occurred. Or a world in which intelligent buildings whisper directions to visitors on the way to their destinations.

"The emerging information grid is going to be far more pervasive than the electric power grid is today," he said.

STILL, the idea that the Internet may transform itself into a global computational grid with a mind of its own has generally been considered far-out stuff from the pages of science fiction novels.

The idea of a thinking machine may sound outrageous, but Dr. Smarr's record has made him one of the world's most respected computer technologists. He created the research center that contributed to the development of the Internet and then invented the graphical browser — marketed as the Netscape Navigator and Internet Explorer — that opened the Net to the masses.

As director of the computer research institute announced on Thursday, he is now in the position to test even his most far-out ideas. The institute will be established with more than $300 million in state and private funds over four years.

Based jointly at the University of California campuses at San Diego and Irvine, it will focus on engineering new types of sensors, creating an advanced digital wireless Internet and designing a new class of distributed-computing machines, which break a problem into separate pieces to speed calculations. It will also work on applying those technologies to problems in the environment and transportation, as well as to genomic medicine and new-media arts.

Several times in the past, Dr. Smarr had equally radical ideas about where computing was headed, and each time he correctly spotted the Next Big Thing.

He founded the National Center for Supercomputer Applications at the University of Illinois at Urbana-Champaign in 1985, and helped to develop a network that linked it to the nation's other four supercomputer centers.

His center also did pioneering work in scientific visualization, and one of its brightest scientists, Stefen Fangmeier, went on to become a leading graphics animator in Hollywood. There, he helped to create special effects for movies like "Jurassic Park" and "The Perfect Storm."

Yet those advances pale beside the fact that seven years ago, a small group of student and faculty researchers working at Dr. Smarr's center created the first graphical Web browser, Mosaic, igniting the World Wide Web and the electronic-commerce explosion.

The center's advances flowed directly from Dr. Smarr's passion over the last three decades: to use powerful computers to improve the quality of science. His goal in developing the supercomputer centers was to give tools to scientists that had once been available only to bomb designers and code breakers.

The Internet and the World Wide Web grew in part from his drive to build better computer tools to permit scientists to collaborate and share information.

"He fostered the kind of environment that I had always associated with Xerox Palo Alto Research Center or Bell Labs," said Marc Andreessen, the Netscape cofounder, referring to two widely admired information technology laboratories. "People were free to follow their instincts. He tends to attract really, really smart people and gives them the latitude to pursue their ideas."

But Mr. Andreessen added that while he was there, the University of Illinois shared at least one weakness with the Xerox lab in Silicon Valley: It had a hard time bringing innovations to the marketplace. Mr. Andreessen was able to start Netscape by licensing the institute's Mosaic technology, but only after overcoming the university's resistance, he said.

"What they never got at N.C.S.A., what they never had, was a culture of entrepreneurial spinoffs," said Mr. Andreessen, adding that the culture had since changed. "If he can add that at the new institute, a culture that permits people to go off and start companies, then I think he will really have something."

OVER one and a half decades at the Illinois supercomputer center, Dr. Smarr built a reputation as a scientist who helped to develop the use of computers by both elite scientists and millions of non-technical Web surfers.

"Larry has had a huge impact," said Robert R. Borchers, director of the division of advanced scientific computing at the National Science Foundation. "He's a legitimate scientist, and he's usually one step or two ahead of the trend on technology."

Dr. Smarr's new institute will draw together more than 200 faculty members at the San Diego and Irvine campuses to re-invent the Internet using technologies like optical fiber cables, digital wireless networks and micro-electro-mechanical systems, or MEMS.

Since the end of the cold war, this part of Southern California has changed from a stronghold of the military and aerospace industries into a center for wireless, optical, semiconductor and biotechnology companies.

Dr. Smarr settled on this area — 400 miles south of Silicon Valley — because it was both a center for high technology and a fertile ground for what he calls "I.P.O. capitalism."

"Based on the electronic-commerce boom that followed the development of the Mosaic Web browser, I realized that a new model of growth was emerging," he said. "I knew I had to get to a place where there was an explosive private sector."

Among the companies that have already committed themselves to investing $140 million in Dr. Smarr's new institute, dubbed Cal-(IT)^2, are **I.B.M., Sun Microsystems, Qualcomm, Boeing, Broadcom, Ericsson, Microsoft, Intersil, ST Microelectronics** and **Sony**.

Dr. Smarr's plan is to use the institute to attack a few very difficult problems with what he calls "megacomputers" — thousands or even millions of separate computers lashed together with optical fibers via the Internet.

The most dramatic challenge for the institute, considering its location in automobile-choked Southern California, is to build a prototype for an "intelligent transportation infrastructure." It would use the Internet to wirelessly link sensor arrays under freeways with computers in cars. Dr. Smarr believes that it will be possible to build a giant computing grid that can control traffic more effectively.

"When your computer knows where each car is planning to go, it is

a problem you can solve," he said.

The challenge is that a computer that large has never been built, much less programmed. Such a machine would have what Dr. Smarr calls an "effervescent" architecture. It would comprise millions of parts — processors, communications links and storage units — that come and go unpredictably.

"Larry's plan is to take the Web into the physical world," said Ramesh Rao, a professor of electrical engineering at the University of California at San Diego.

Many people in the computer industry believe that if such a machine is to be built, Dr. Smarr is the ideal person to lead the quest.

"He has long years of experience in the hardest part of this whole business," said Richard Shaffer, president of Technological Partners, a computer industry consulting firm. "That's getting software to work together across lots and lots of processors."

Dr. Smarr's obsessive search for more computing speed derived from his theoretical work as a student in the 1970's. Then, as a first-year graduate student at Stanford, he was trying to apply Einstein's general theory of relativity to the collision of two black holes.

At the time, the only way to get access to enough computer power to start the experiments needed to test his theories was to turn to the nation's nuclear weapons laboratories.

Dr. Smarr had gone to Stanford to study with Leonard Schiff, one of the world's leading experts in relativity theory. But Dr. Schiff died unexpectedly during Dr. Smarr's first year in graduate school. After moving to the University of Texas at Austin, Dr. Smarr linked up with another group of relativity experts. He eventually received a Ph.D.

AT Texas, his adviser told him bluntly to get top-secret nuclear weapons clearance so he could go to the Lawrence Livermore National Laboratory in California and "learn from the great ones."

For Dr. Smarr, contact with the weapons labs was what he now describes as a Promethean experience. Early on, he found that a problem that would take eight hours to run on a Digital Equipment VAX computer at the University of Texas would require just two minutes on one of the weapons laboratories' supercomputers.

Several years later, as a post-doctoral researcher at Harvard, he was a regular visitor at weapons labs, flying in for a few days at a time and cadging time on supercomputers to run simulations of thermonuclear forces far more awesome than the hydrogen-bomb makers had imagined.

"It was what I called 'interstitial' living," he said. "I would show up on Friday afternoons and ask, 'Hey, are you guys going to be running your bomb codes this weekend?' "

The experience transformed him. The lab visits were like ventures into an advanced civilization with powerful tools beyond the grasp of mere mortals.

"I remember going back to Harvard and feeling like being an alien landing on a primitive planet," he said.

In 1983, as a junior faculty member at the University of Illinois at Urbana-Champaign, Dr. Smarr did something unprecedented. He sent an unsolicited, $50 million proposal to the director of the National Science Foundation, George Keyworth. In it, he called for the creation of a supercomputer center at the university to give civilian scientists the same access to powerful computers that was enjoyed at the nation's weapons labs.

At about the same time, Sid Karin, a scientist at General Atomics, a contractor at the University of California at San Diego, sent a similar proposal to the government. Two years later, the National Science Foundation acted, setting up a nationwide network of five centers dedicated to broadening scientific access to supercomputers.

Dr. Smarr still frets over how little the nation supports both the direct and indirect benefits of the centers. "What our society doesn't understand is how critical investment in basic science and technology is to advances in society," he said.

California is counting on such a spinoff effect from its three new research institutes.

Dr. Smarr draws parallels to the nation's land-grant universities of more than 100 years ago. "This is really just back to the future," he said. "Why did the citizens of the Midwest allow their tax dollars to be spent on agricultural research? Because it led directly to more economic productivity."

And what America's agrarian economy of the 19th century found in basic scientific research, Dr. Smarr sees in the proliferation of networked microprocessors in the next decade. Not only is the power of individual computer processors growing at an exponential rate, but the number of interconnected computers and computing devices is exploding.

On Monday, at the San Francisco conference, Dr. Smarr described a networked world in which the number of personal computers would soon double, to one billion. Moreover, there will soon be three billion Internet-connected cell phones — and, more important, as many as 16 billion Internet-connected computers embedded in everything from automobiles to toasters.

It is a world, he said, in which a world of Net-connected computers and electronic sensors "overlay" the real world in such a way that computer power enhances every human

action. For example, he sees a time when supercomputers let scientists see hurricane damage as it occurs, as spy satellites work for the military today.

"We're talking about something very radical," he said. "This is the world we're coming to. It's an enchanted world where everything has processors in it linked by the Internet."

HE defends his vision of the future of cyberspace with the certainty of a physicist. Computer processing power is advancing so rapidly, he said, that society is likely to soon go through a revolution as dramatic as the "phase change" when water changes into ice.

For that reason, Dr. Smarr said he plans to hold regular conferences at Cal-(IT)^2 about the consequences of scientific and technological change.

Dr. Smarr is not the only computer researcher grappling with the social consequences of wildly accelerating computer power. William Joy, cofounder of Sun Microsystems, recently wrote an article in Wired magazine warning about the potential perils of intelligent machines. Two well-known computer researchers, Hans Moravec and Raymond Kurzweil, have also written books this year about the likelihood of the emergence of intelligent machines.

Mr. Joy's article has touched off a debate among computer scientists about the consequences of their work. Dr. Smarr said he believes that computer scientists may need to grapple with the challenges, perhaps meeting in the same way as biologists did in 1975 at the Asilomar Conference to face the ethical challenges of biotechnology.

In Dr. Smarr's Brave New Cyberspace, the answer shouldn't be long in coming. □

Net Gains

Some highlights in Larry Smarr's career promoting the Internet.

Fall 1983 Dr. Smarr writes a proposal to the National Science Foundation, requesting a supercomputer for the University of Illinois at Urbana-Champaign. Ralph Simmons, then head of the physics department, travels with Dr. Smarr to deliver the unsolicited proposal, addressed simply to "Director, N.S.F."

March 1985 The National Center for Supercomputer Applications is established under a five-year foundation grant.

April 1987 An advanced scientific graphics program begins at the supercomputer center.

Fall 1987 NCSA Telnet, the center's first major software release, makes its debut. By 1991 it has more than 100,000 users.

October 1988 A Cray-2 supercomputer is installed. It has four processors and can perform about 1.7 billion calculations a second.

April 1993 NCSA Mosaic, the first user-friendly Web browser, is released. At the time, there are about 200 World Wide Web servers in the world.

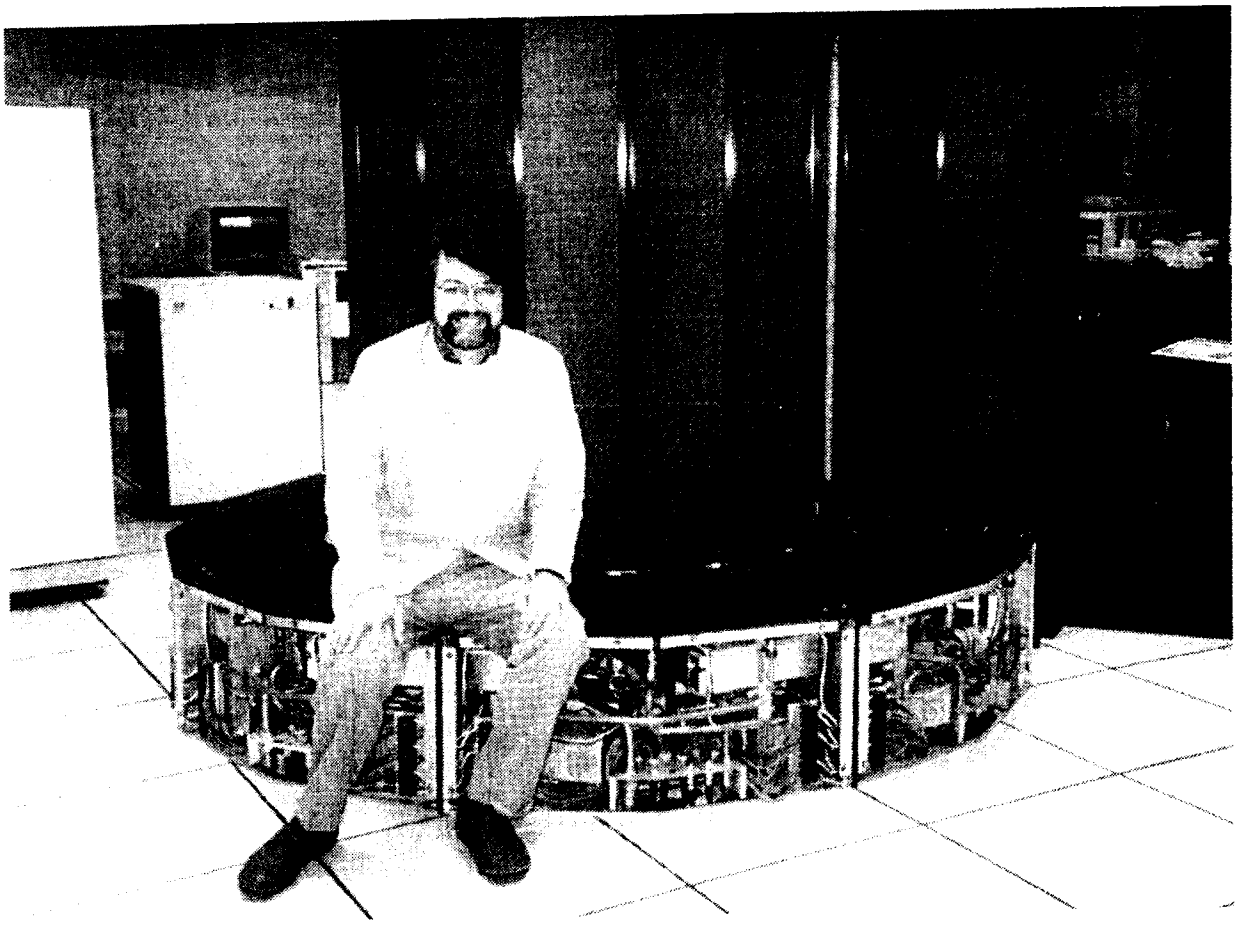
1994 Mosaic has several million users and has effectively given birth to the dot-com industry, which is projected to be worth $1 trillion by 2001.

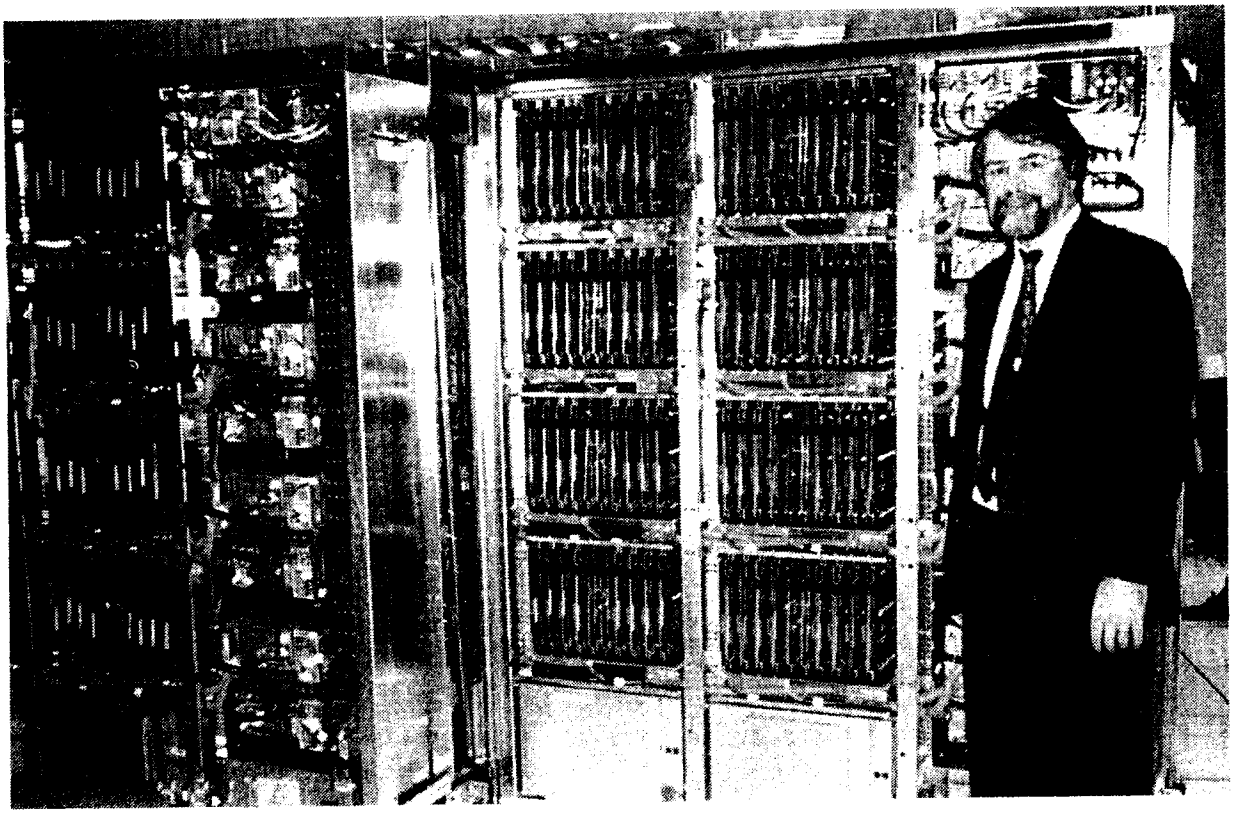
February 1997 Dr. Smarr is appointed to the President's Information Technology Advisory Committee.

October 1997 The National Computational Science Alliance becomes a reality. A partnership of some 50 institutions across the country, it is charged with making a prototype of the National Technology Grid. "This is an unprecedented effort in which the whole is truly greater than the sum of its parts," Dr. Smarr says. "In essence, we are establishing a virtual community that shares its knowledge and pools its resources to create the computational and information infrastructure of the 21st century that will support the next generation of scientific and engineering research."

May 2000 Dr. Smarr joins the computer science and engineering faculty at the University of California at San Diego. Relying on the national distributed-computing network that he has helped advance for more than 15 years, he remains an adviser to the National Computational Science Alliance.

Source: National Center for Supercomputing Applications, University of Illinois at Urbana-Champaign





Larry Smarr, an astrophysicist, helped spur the creation of the National Center for Supercomputer Applications when he was teaching at the University of Illinois in Urbana-Champaign in 1985; there, he worked with machines like the Cray Y-MP, top, in 1988 and the Thinking Machines CM-5, above, in 1993.