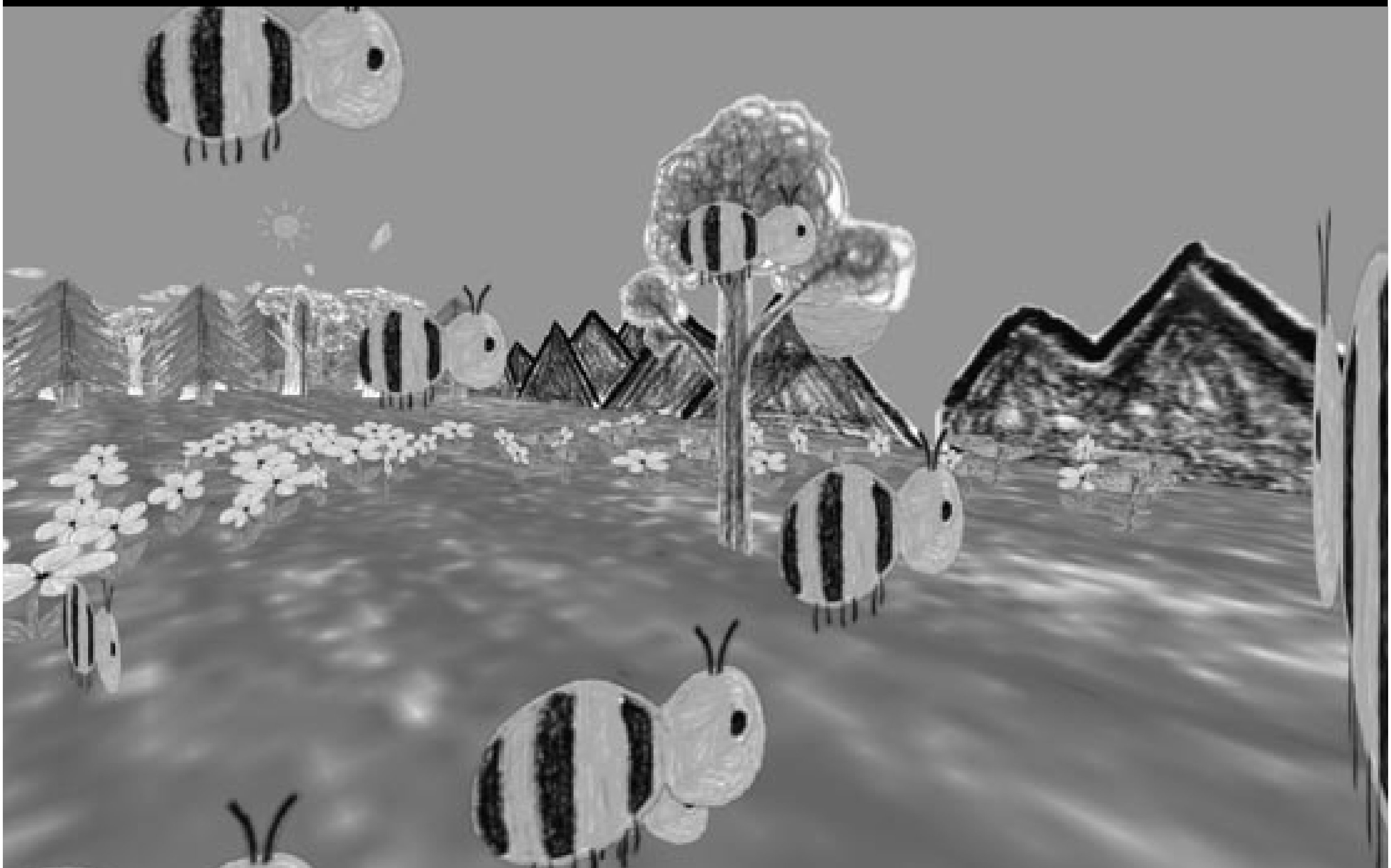
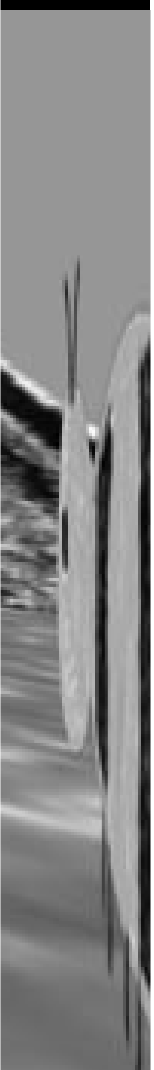


Crayoland. Anti-photorealistic and interactive, this virtual 3D environment is built entirely from 2D crayon drawings. (Courtesy Dave Pape, EVL, University of Illinois at Chicago.)



# The NSF Partnerships and the Tradition of U.S. Science and Engineering

**The National Science Foundation's Partnership for Advanced Computational Infrastructure (PACI) initiative is a bold step in terms of vision and scale even when set against the remarkable progress in computational science and the supercomputer and network developments of the past 30 years.**

The two PACI successors to the NSF Supercomputer Centers program—the National Computational Science Alliance and the National Partnership for Advanced Computational Infrastructure (NPACI)—constitute an exciting new venture for the U.S. and its science and engineering enterprise. If the goals outlined by my colleagues in the articles in this special section of *Communications* are achieved, and I am sure they can be, much of the science and engineering in U.S. universities, industry research centers, and national laboratories will be transformed over the next decade.

The NSF Supercomputer Centers program, which began in 1985 and ended September 30, 1997, was instrumental in advancing science and engineering research and in enabling U.S. world leadership in computational science and engineering. In 1994, after two studies of the program [1, 2], NSF appointed a task force of distinguished computer experts to consider the need for continued NSF support for an advanced computational infrastructure. In its 1995 report, the Task Force on the Future of the NSF Supercomputer Centers Program, chaired by Ed Hayes, vice president for research at Ohio State University, made a number of recommendations [3]. The principal one was that: In order to maintain world leadership in computational science and engineering, NSF should continue to maintain a strong, viable Advanced

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Scientific Computing Centers program, whose mission is to:

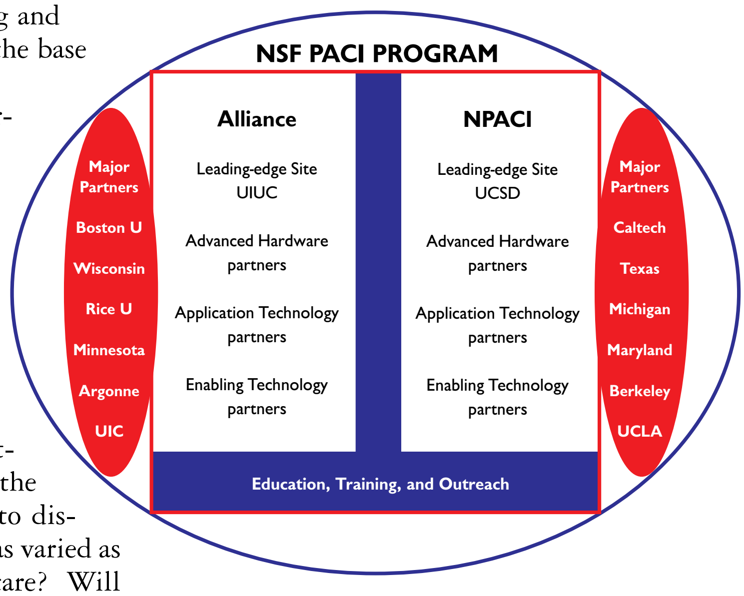
- Provide access to high-end computing infrastructure for the academic scientific and engineering community
- Partner with universities, states, and industry to facilitate and enhance that access
- Support the effective use of such infrastructure through training, consulting, and related support services
- Be a vigorous early user of experimental and emerging high-performance technologies offering high potential for advancing computational science and engineering
- Facilitate development of the intellectual capital required to maintain world leadership

PACI is based on the concept of partnerships—needed because so much innovation now comes from the research community beyond the NSF Centers. The U.S. has the world's best federal program for funding individual and small-group basic research. As a result, a constant stream of innovation is emerging from its universities and government laboratories. However, the three traditional means of transferring this knowledge to the commercial market—moving people from universities to industry, publishing papers, and licensing intellectual property—have two major shortcomings: The pace of transfer is slow relative to the market's rate of change and the things transferred are individual ideas. Needed is the ability to quickly and smoothly transfer whole approaches, bodies of knowledge, and R&D processes, in addition to the traditional technology transfer mechanisms.

Therefore, a major goal of the PACI program is to form a national-scale effort to accelerate the synthesis of new research ideas, moving them quickly into practice. The partnerships involve a strong coalition of computer scientists, computational scientists, and professionals in education, outreach, and training, working together with industrial partners to prototype the information and computational infrastructure of the early 21st century (see Figure). As recommended by the Task Force and called for in the PACI program solicitation, each partnership will operate a leading-edge site that maintains high-end hardware systems one to two orders of magnitude more capable than those typically available at a major research university. In addition, partner activities are organized in the following ways:

- Advanced Hardware partners, providing access to a diverse set of advanced midrange computers and data storage systems, as well as to experimental machine architectures
- Application Technology partners, engaging in high-end applications to develop and optimize their discipline-specific codes and software infrastructures and make them available to the program as a whole, as well as to researchers in other areas
- Enabling Technology partners, developing software tools for both parallel computing and heterogeneous computing on geographically distributed, architecturally diverse machines and data sources
- Education, Outreach, and Training partners, ensuring growing awareness and understanding of

how to use high-performance computing and communications resources, broadening the base of participation, and ultimately helping ensure the U.S.'s continued world leadership in computational science and engineering




NSF PACI program

## In the Tradition of U.S. Science and Engineering?

Is the NSF plan and the response it requires from the science and engineering communities too audacious? Too large? Is it possible to bring together so many diverse players from institutional settings with vastly different cultures? Can the new technologies really be disseminated to disparate scientific disciplines and to sectors as varied as transportation, education, and health care? Will industry and the service sectors really use the new computing power, adapting the applications for their own needs?

The vision is bold but viewed in another context is squarely within the tradition of U.S. science and engineering. The partnerships continue a pattern set nearly 60 years ago when U.S. scientists and engineers mobilized for scientific R&D in World War II under the leadership of Vannevar Bush, head of the wartime Office of Scientific Research and Development and an early computer scientist. The scale and scope of cooperation among scientists, engineers, industry, and government was unprecedented but proved quite effective. The experience gained set in motion a long-lasting pattern of collaboration among scientists, engineers, and government R&D agencies.

In the 1950s, geophysical scientists in the U.S. and 66 other nations, working with their governments, organized the highly successful International Geophysical Year. They established a worldwide network of 2,500 observatories staffed by 10,000 scientists for synoptic observations and coordinated exploratory and research expeditions. In the 1960s, astronomers and oceanographers devised ways to equitably allocate observing time on the new telescopes and research ships then being built by NSF and the Office of Naval Research. Atmospheric scientists in the U.S. and other nations, working with their governments, developed and carried out the Global Atmospheric Research program. The historic Voyager missions to the outer planets in the 1970s and 1980s required the dedicated effort of space scientists and engineers over 15 years. On another scientific frontier and more recently, U.S. molecular biologists, working with the National Research Council and government agencies, developed the Human Genome Program to coordinate mapping and sequencing activities and foster the exchange of data and biomaterials.

Each of these programs and many others I could cite was initiated with a bold vision of new scientific opportunity. Each required scientists and engineers in different sectors—university, industry, and government—to have an ambitious research agenda, devise new ways of working together, and push the frontiers of technology and instrumentation. There were many unknowns along the way, but they were solved by dedicated scientists and engineers and government sponsors collaborating as a team. The Alliance and NPACI continue this U.S. tradition. C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