EDITORIAL

Computing: Networks and Modeling

Computers and computing have changed the modern world, but the effects on the practice of science have been especially profound. The impacts now extend far beyond simple numerical computation and extend into the realms of complex simulations and knowledge retrieval as well. In this issue of *Science* we concentrate on computer networks and powerful methods for modeling the natural world.

NCSA Mosaic and the World Wide Web have made access to a marvelous range of information available to Everyperson. Mosaic software can bring the world of linked text, graphics, sound, and video to anyone with a desktop computer and a link to the Internet. It is no longer necessary to be an expert to navigate through the world's available information space and find and retrieve items of interest. Schatz and Hardin present an overview of the important issues by describing the workings of Mosaic. They discuss the protocols and services that make it possible to access and use a global hypermedia system.

This is the future of networking, and still more powerful tools may be on the horizon, as Waldrop discusses in his news story on intelligent agents. These mobile software robots could roam the networks on behalf of the human user, collecting and sorting information themselves. Accompanying these bright prospects are some anxieties, examined in another story by Waldrop. With the explosive growth of the Internet and its increasing commercialization, some users say changes in access and pricing are inevitable, and they are seeking ways to minimize the impact of these changes on research and education.

Computation, however, remains at the heart of much of science. Martino, Johnson, Suh, Trus, and Yup describe applications of parallel computing at the National Institutes of Health. Because of the range of problems that require massive computer resources, biomedical science is an important arena for parallel computing. The tasks include processing electron micrographs for three-dimensional structures of viruses, calculating accessible surface areas of proteins to predict their conformations and searching DNA sequences for homology. Importantly, developments in compiler technology are beginning to make possible the conversion of many programs to parallel computing.

High-performance computation has also opened the way to far more sophisticated simulations and displays. As described in Freedman and Taubes' news stories about computer models of the immune system and the brain's cognitive processes, computer simulation is doing for some biologists what it did in the past for physicists. It is giving them a computational laboratory in which to test ideas that can later be verified in natural systems. In another story, Taubes surveys how computing muscle and technical ingenuity are combining in virtual reality displays that make vast data sets or simulations easier to comprehend and explore.

No matter how fancy the hardware and the software, the mathematics behind computations is critical. Greengard addresses some of the new ways to deal with fundamental problems in physics. Fast summation methods for evaluating pairwise interactions of N particles are described that permit relatively modest resources to be used to study problems such as diffusion, gravitation, and wave propagation.

In his Perspective, Hendler describes some of the advances in artificial intelligence made possible by new hardware and software. Scientists are struggling with the data that gushes from the scientific well, and the flood of information requires new knowledge tools. Very large knowledge databases present an important challenge, and this Perspective examines some of the critical issues in this area.

Grimshaw discusses generalized resources for computing across entire networks. The goal is to provide the user with a single virtual machine encompassing widely networked processors and databases. The enabling factors are the incredible increase in network speed (10^9 bits per second), and the ability to link systems that contain different processors and operating systems. These advances not only make it possible to do much faster computing, they also make it possible to utilize resources much more effectively.

Almost all areas of science are benefiting directly from these advances. In many ways, growth of the global Internet and improvements in computing power are catalyzing completely new ways of doing research. One can only watch with wonder at the speed with which this is happening.

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