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EDITORIAL

Knowledge and Distributed Intelligence

In reading the pages of *Science*, I have been struck by the stunning progress being made in science and engineering—new phenomena discovered, new materials synthesized, new methods developed. What I see behind many of these exciting stories is the widespread and even revolutionary use of distributed intelligence that is made possible by the "wiring" of the scientific community. It is more than a time saver or a communication enhancer; it is enabling us to think in new ways and its impact on society may be monumental.

Consider this random sampling of newspaper headlines: "Medical Schools Use Palmtop Computers to Improve Training," "Web Site Allows Users to 'Handle' Specimens From Smithsonian," "Laugh and Your Computer Will Laugh With You, Someday." There's obviously something profound going on here, and it is more than just the Internet. Computational technologies are becoming more powerful and more portable. We can access more information at greater speeds and with greater facility than was previously imaginable. We can even remotely control sophisticated experiments—on a recent visit to the National Science Foundation's (NSF's) South Pole Station, I watched as astronomers in Wisconsin controlled an infrared telescope on site. As these advances in computing and communications coalesce, we begin to see their full potential for promoting progress in science and engineering and for driving economic growth and societal gain.

The term "information age" probably does not do justice to the possibilities of this emerging era. This is an age of "knowledge and distributed intelligence," in which knowledge is available to anyone, located anywhere, at any time; and in which power, information, and control are moving from centralized systems to individuals. This era calls for a new form of leadership and vision from the academic science and engineering community. We know from countless examples that academic science and engineering have enabled our society to make the most of new technologies. We wouldn't have today's advanced computer graphics systems if mathematicians hadn't been able to solve problems related to surface geometries. We wouldn't have networks capable of handling massive amounts of data if physicists and astronomers hadn't continuously forged tools to look more deeply into subatomic structures and the cosmos. Chemists' efforts to simulate complex phenomena and predict the properties of many-electron systems have inspired massively parallel architectures for computing. And the information made available by the sequencing of the human genome has caused us to rethink how to store, manipulate, and retrieve data most effectively. It will take new insights from studies of human cognition, linguistics, neurobiology, computing, and more to develop systems that truly augment our capacity to learn and create. The best may be yet to come.

Despite brutally tight constraints on federal discretionary spending, President Clinton has stepped forward to champion a 3 percent increase (uncorrected for inflation) in NSF's 1998 budget. The president's request is only the first step in the congressional budget process ahead. Given that the priorities of Congress will almost certainly differ from those of the president, it will take an unprecedented level of input and commitment from the research community to ensure that investments in science and engineering receive the same strong bipartisan support they have enjoyed for generations. This 3 percent increase would enable NSF to launch a new set of investments spanning all its directorates. This knowledge and distributed intelligence (KDI) initiative would promote collaborations that seem long overdue, such as linking the science of learning and cognition with the development of technologies for teaching and learning. NSF's role in the proposed Next Generation Internet project is also part of the KDI package. This project would create a "smart" infrastructure for research and education at colleges and universities that would facilitate collaboration across geographic as well as intellectual distances.

It is clear that knowledge and distributed intelligence holds immense potential, both from a scientific standpoint and as a driver of progress and opportunity for all Americans. Knowledge and distributed intelligence is not just about hardware or software, but about the wherewithal to change for the better the way we learn, communicate, and do research.

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