

An Endless Frontier Postponed

Next month, U.S. scientists Vinton G. Cerf and Robert E. Kahn will receive computing's highest prize, the A. M. Turing Award, from the Association for Computing Machinery. Their Transmission Control Protocol (TCP), created in 1973, became the language of the Internet. Twenty years later, the Mosaic Web browser gave the Internet its public face. TCP and Mosaic illustrate the nature of computer science research, combining a quest for fundamental understanding with considerations of use. They also illustrate the essential role of government-sponsored university-based research in producing the ideas and people that drive innovation in information technology (IT).

Recent changes in the U.S. funding landscape have put this innovation pipeline at risk. The Defense Advanced Research Projects Agency (DARPA) funded TCP. The shock of the Soviet satellite Sputnik in 1957 led to the creation of the agency, which was charged with preventing future technological surprises. From its inception, DARPA funded long-term nonclassified IT research in academia, even during several wars, to leverage all the best minds. Much of this research was dual-use, with the results ultimately advancing military systems and spurring the IT industry.

U.S. IT research grew largely under DARPA and the National Science Foundation (NSF). NSF relied on peer review, whereas DARPA bet on vision and reputation, complementary approaches that served the nation well. Over the past 4 decades, the resulting research has laid the foundation for the modern micro-processor, the Internet, the graphical user interface, and single-user workstations. It has also launched new fields such as computational science. Virtually every aspect of IT that we rely on today bears the stamp of federally sponsored research. A 2003 National Academies study provided 19 examples where such work ultimately led to billion-dollar industries, an economic benefit that reaffirms science advisor Vannevar Bush's 1945 vision in *Science: The Endless Frontier*.

However, in the past 3 years, DARPA funding for IT research at universities has dropped by nearly half. Policy changes at the agency, including increased classification of research programs, increased restrictions on the participation of noncitizens, and "go/no-go" reviews applied to research at 12- to 18-month intervals, discourage participation by university researchers and signal a shift from pushing the leading edge to "bridging the gap" between fundamental research and deployable technologies. In essence, NSF is now relied on to support the long-term research needed to advance the IT field.

Other agencies have not stepped in. The Defense Science Board noted in a recent look at microchip research at the Department of Defense (DOD): "[DARPA's] withdrawal has created a vacuum . . . The problem, for DOD, the IT industry, and the nation as a whole, is that no effective leadership structure has been substituted." The Department of Homeland Security, according to a recent report from the President's Information Technology Advisory Committee, spends less than 2% of its Science and Technology budget on cybersecurity, and only a small fraction of that on research. NASA is downsizing computational science, and IT research budgets at the Department of Energy and the National Institutes of Health are slated for cuts in the president's fiscal year 2006 budget.

These changes, combined with the growth of the discipline, have placed a significant burden on NSF, which is now showing the strain. Last year, NSF supported 86% of federal obligations for fundamental research in IT at academic institutions. The funding rate for competitive awards in the IT sector fell to 16%, the lowest of any directorate. Such low success rates are harmful to the discipline and, ultimately, to the nation.*

At a time when global competitors are gaining the capacity and commitment to challenge U.S. high-tech leadership, this changed landscape threatens to derail the extraordinarily productive interplay of academia, government, and industry in IT. Given the importance of IT in enabling the new economy and in opening new areas of scientific discovery, we simply cannot afford to cede leadership. Where will the next generation of groundbreaking innovations in IT arise? Where will the Turing Awardees 30 years hence reside? Given current trends, the answers to both questions will likely be, "not in the United States."

Edward D. Lazowska and David A. Patterson

Edward D. Lazowska holds the Bill & Melinda Gates Chair in Computer Science & Engineering at the University of Washington. David A. Patterson holds the E. H. and M. E. Pardee Chair of Computer Science at the University of California, Berkeley, and is president of the Association for Computing Machinery. Both are members of the National Academy of Engineering and the President's Information Technology Advisory Committee, and past chairs of the Computing Research Association.

*The House Science Committee will consider these issues at a 12 May hearing on "The Future of Computer Science Research in the U.S." See <http://www.cra.org/research>.

