THE NATIONAL ACADEMIES
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Innovation in Information Technology—*Summary*

COMPUTER SCIENCE AND TELECOMMUNICATIONS BOARD

Background

The health of the computer science field and related disciplines has been an enduring concern of the National Research Council's Computer Science and Telecommunications Board (CSTB). From its first reports in the late 1980s, CSTB has examined the nature, conduct, scope, and directions of the research that drives innovation in information technology. Ironically, the success of the industries that produce information technology (IT) has caused confusion about the roles of government and academia in IT research. And it does not help that research in computer science—especially research relating to software—is hard for many people outside the field to understand. In order to explain the what and why of IT research, members of the Board developed a synthesis report drawing on several CSTB reports, published over the course of the past decade, and on insights and experience from their own careers.

Findings and Recommendations

Progress in information technology (IT) has been remarkable, but the best truly is yet to come: the power of IT as a *human enabler* is just beginning to be realized. Whether the nation builds on this momentum or plateaus prematurely depends on today's decisions about fundamental research in computer science (CS) and the related fields behind IT.

The Computer Science and Telecommunications Board (CSTB) has often been asked to examine how innovation occurs in IT, what the most promising research directions are, and what impacts such innovation might have on society. Consistent themes emerge from CSTB studies, notwithstanding changes in information technology itself, in the IT-producing sector, and in the U.S. university system, a key player in IT research.

In this synthesis report, based largely on the eight CSTB reports enumerated below, CSTB highlights these themes and updates some of the data that support them. Much of the material is drawn from (1) the 1999 CSTB report *Funding a Revolution: Government Support for Computing Research*, written by both professional historians and computer scientists to ensure its objectivity, and (2) *Making IT Better: Expanding Information Technology Research to Meet Society's Needs,* the 2000 CSTB report that focuses

on long-term goals for maintaining the vitality of IT research. Many of the themes achieved prominence in (3) the 1995 CSTB report *Evolving the High Performance Computing and Communications Initiative to Support the Nation's Information Infrastructure*, known informally as the Brooks-Sutherland report. Other reports contributing to this synthesis include (4) *Computing the Future: A Broader Agenda for Computer Science and Engineering* (1992), (5) *Building a Workforce for the Information Economy* (2001), (6) *Academic Careers in Experimental Computer Science and Engineering* (1994), (7) *Embedded, Everywhere: A Research Agenda for Networked Systems of Embedded Computers* (2001), and (8) *More Than Screen Deep: Toward Every-Citizen Interfaces to the Nation's Information Infrastructure* (1997).

Here are the most important themes from CSTB's studies of innovation in IT (the numbers refer to the CSTB reports cited above):

- *The results of research*
  - America's international leadership in IT—leadership that is vital to the nation—springs from a deep tradition of research (1, 3, 4).
  - The unanticipated results of research are often as important as the anticipated results—for example, electronic mail and instant messaging were by-products of research in the 1960s that was aimed at making it possible to share expensive computing resources among multiple simultaneous interactive users (1, 3).
  - The interaction of research ideas multiplies their impact—for example, concurrent research programs targeted at integrated circuit design, computer graphics, networking, and workstation-based computing strongly reinforced and amplified one another (1-4).
- *Research as a partnership*
  - The success of the IT research enterprise reflects a complex partnership among government, industry, and universities (1-8).
  - The federal government has had and will continue to have an essential role in sponsoring fundamental research in IT—largely university-based—because it does what industry does not and cannot do (1-8). Industrial and governmental investments in research reflect different motivations, resulting in differences in style, focus, and time horizon (1-3, 7, 8).
  - Companies have little incentive to invest significantly in activities whose benefits will spread quickly to their rivals (1, 3, 7). Fundamental research often falls into this category. By contrast, the vast majority of corporate research and development (R&D) addresses product and process development (1, 2, 4).
  - Government funding for research has leveraged the effective decision making of visionary program managers and program office directors from the research community, empowering them to take risks in designing programs and selecting grantees (1, 3). Government sponsorship of research especially in universities also helps to develop the IT talent used by industry, universities, and other parts of the economy (1-5).
- *The economic payoff of research*
  - Past returns on federal investments in IT research have been extraordinary for both U.S. society and the U.S. economy (1, 3). The transformative effects of IT

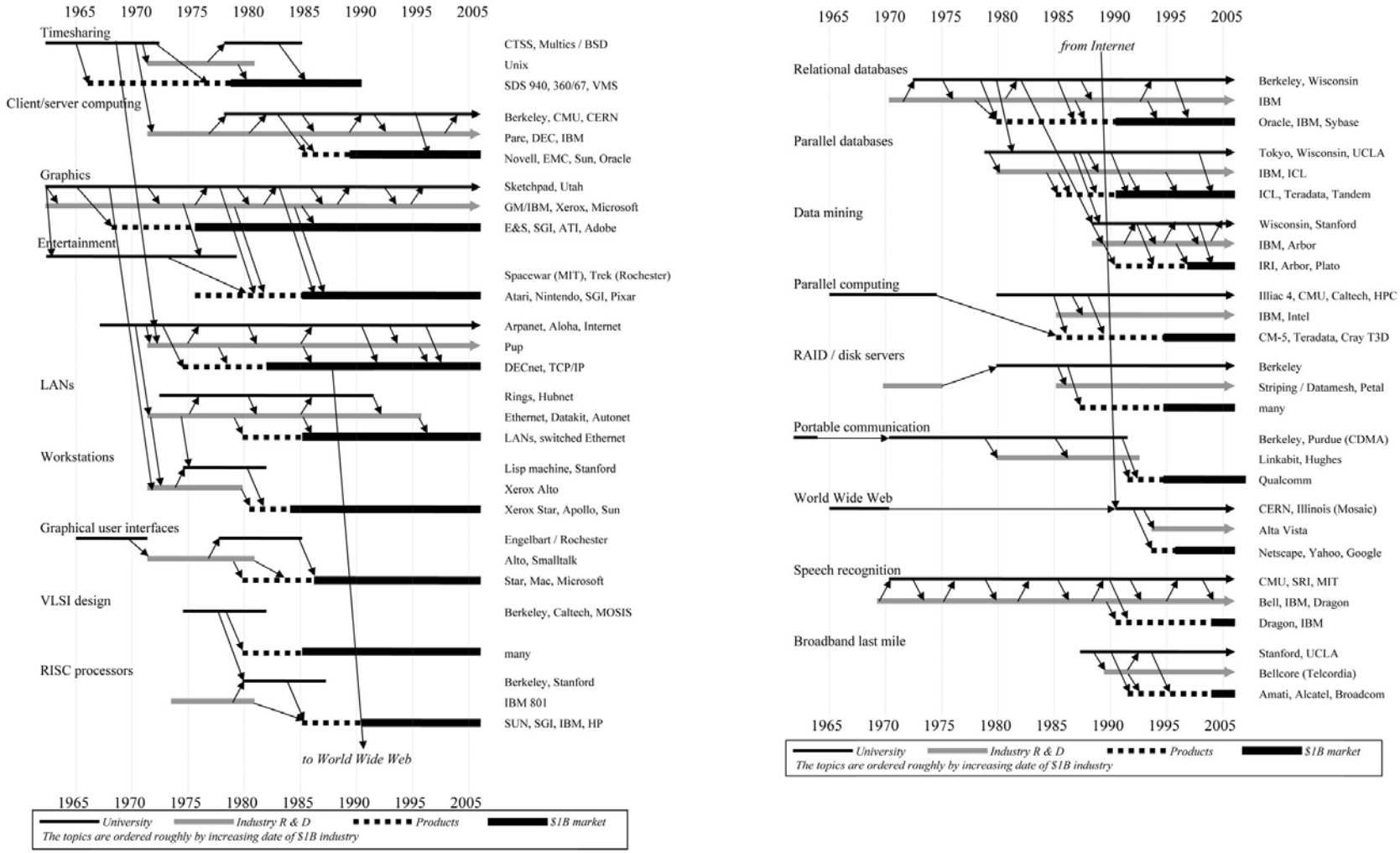
grow as innovations build on one another and as user know-how compounds. Priming that pump for tomorrow is today's challenge.
- When companies create products using the ideas and workforce that result from federally sponsored research, they repay the nation in jobs, tax revenues, productivity increases, and world leadership (1, 3, 5).

The themes highlighted above underlie two recurring and overarching recommendations evident in the eight CSTB reports cited:

Recommendation 1. The federal government should continue to boost funding levels for fundamental information technology research, commensurate with the growing scope of research challenges (2-4, 6-8). It should ensure that the major funding agencies, especially the National Science Foundation and the Defense Advanced Research Projects Agency, have strong and sustained programs for computing and communications research that are broad in scope and independent of any special initiatives that might divert resources from broadly based basic research (2, 3).

Recommendation 2. The government should continue to maintain the special qualities of federal IT research support, ensuring that it complements industrial research and development in emphasis, duration, and scale (1-4, 6).

The report addresses the ways that past successes can guide federal funding policy to sustain the IT revolution and its contributions to other fields.



This figure shows cases where fundamental research in information technology, carried out in industry and universities, led to new product categories with billion-dollar markets. It illustrates the complexity of the flows between government, industry, and academia.

For additional information;

Copies of *Innovation in Information Technology* are available from the National Academies Press; call (800) 624-6242 or (202) 334-3314 (in the Washington metropolitan area), or visit the NAP Web site at <http://www.nap.edu/catalog/10795.html>

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