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Viewpoint
Envisioning the Future of Computing Research

Advances in computing have changed our lives—the Computing Community Consortium aims to help the research community continue that lineage.

How can we work together to establish, articulate, and pursue compelling visions for our field—visions that will shape the intellectual future of the field, that will catalyze research investment and public support, and that will attract the best and brightest minds of a new generation?

The National Science Foundation asked the Computing Research Association to create the Computing Community Consortium (CCC) to address this challenge. The mechanics of the CCC have been described elsewhere;[5] in this column, I focus on the substance.

Computing has Made Extraordinary Progress

William Shockley, Walter Brattain, and John Bardeen invented the transistor at Bell Laboratories in 1947, just over 60 years ago. Jack Kilby at Texas Instruments and Bob Noyce at Fairchild Semiconductor demonstrated the integrated circuit only 50 years ago, in 1958. It was 1965—just a bit more than 40 years ago—when Gordon Moore described what is now universally referred to as "Moore's Law."

Today, the computational power of an early mainframe can be found in an electronic greeting card, and the computational power that guided Apollo 11 to the moon is contained in a Furby electronic toy. There are more than one billion PCs, and nearly that many Internet hosts.

It was only 10 years ago that Deep Blue—a supercomputer by any definition—defeated world chess champion Garry Kasparov. Today, thanks more to progress in software than to progress in hardware, you can download for your PC a chess engine with a rating 10% higher than any human player. Most of the "futurist scenarios" described when *Time* magazine featured the computer as "Machine of the Year" 25 years ago have been realized, including computer-controlled tailoring using laser-scanning, robots performing domestic chores, embedded systems that people don't realize are computers at all.

Advances in computing are changing the way we live, work, learn, and communicate. These advances are driving advances in nearly all other fields and are significantly influencing the U.S. economy—not just through the growth of the IT industry, but even more importantly, through productivity growth across all sectors.

Research has Laid the Foundation

Almost every aspect of computing that is integral to our lives today can trace its roots, at least in substantial part, to federally sponsored research. In 1995, the National Academies' "Brooks-Sutherland Report"[2] traced the lineage of a number of billion-dollar sub-sectors of the computing industry: timesharing, computer graphics, networking (LANs and the Internet), personal workstation computing, windows and the graphical user interface, RISC architectures, modern integrated circuit design, RAID storage, and parallel computing. In each case, the role of federally sponsored research was clear.

The panel conducting this study (I was one of the 12 members) lamented our inability to identify new ideas that might someday be comparably influential. But eight years later, the National Academies did a reprise of the study[4] and noted entertainment technology, data mining, portable communication, the Web, speech recognition, and broadband last mile as new billion-dollar subsectors whose roots could be traced, at least in substantial part, to federally sponsored research. (The figure on the next page shows the approximate time frame from concept to billion-dollar industry.)

While we may not be sure which they are, there surely are technologies in our laboratories today that will have comparable impact a decade from now.

The Future is Full of Opportunity

Several months ago, the National Academy of Engineering unveiled 14 "Grand Challenges for Engineering" for the 21st century.[3] The majority of these "Grand Challenges" for *all* of engineering have either substantial or preponderant computer science content:

- Secure cyberspace
- Enhance virtual reality
- Advance health information systems
- Advance personalized learning
- Engineer better medicines
- Engineer the tools of scientific discovery
- Reverse-engineer the brain
- Prevent nuclear terror (to a great extent a sensor network and data mining problem)

These are, in every way, visions that can shape the intellectual future of our field, catalyze research investment and public support, and attract the best and brightest minds of a new generation. And there are many more such visions:

- Create the future of networking
- Empower the developing world through appropriate information technology
- Design automobiles that don't crash
- Build truly scalable computing systems
- Engineer advanced "robotic prosthetics"—the field of Neurobotics
- Instrument your body as thoroughly as your automobile
- Engineer biology (synthetic biology)
- Achieve quantum computing

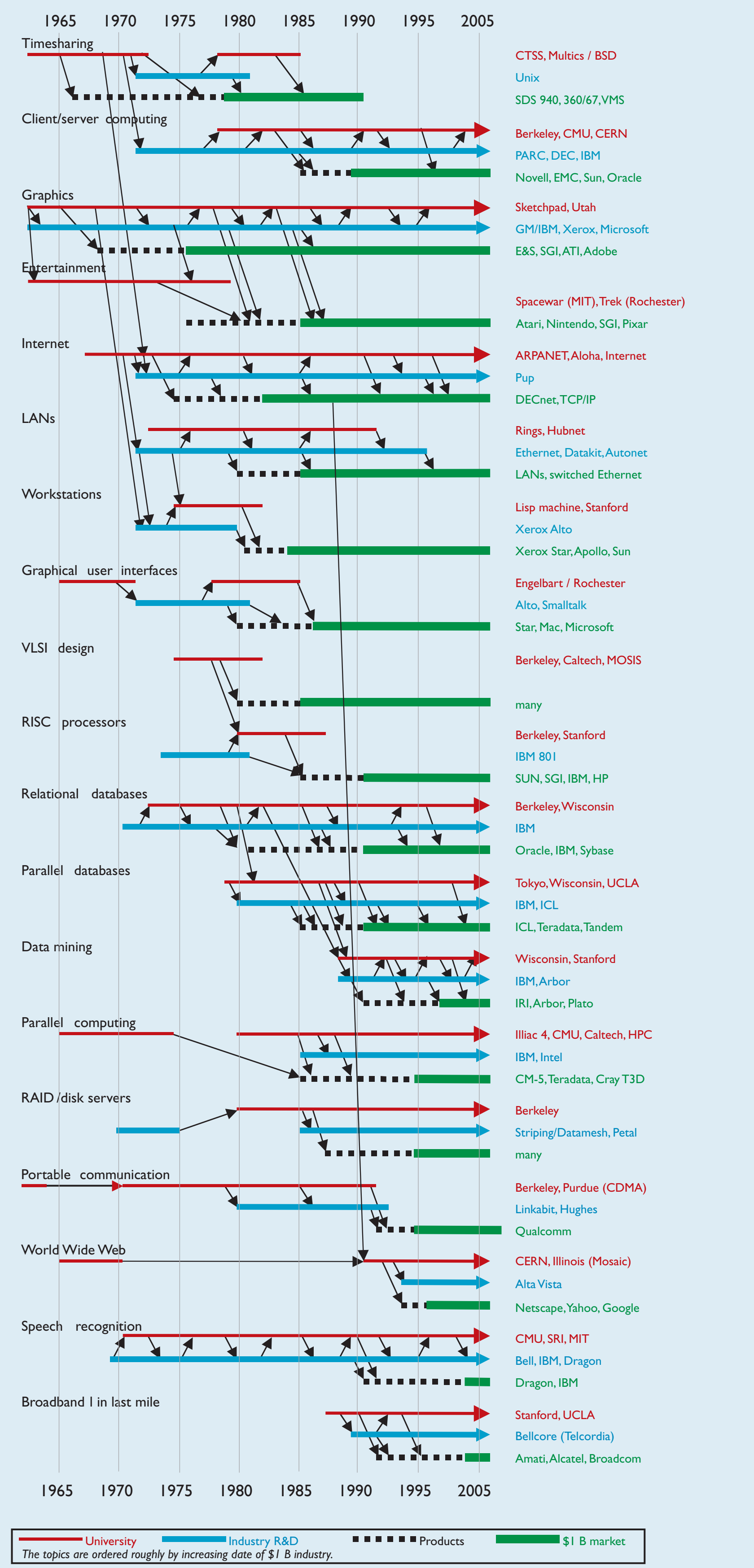
It is very difficult to imagine a field with greater opportunity to change the world.

The Role of the Computing Community Consortium

The role of the Computing Community Consortium is to help our field "put the meat on the bones" of visions such as these. For each of these visions—and for others—we must work together to build a research community, lay out a research roadmap, and acquire momentum.

One way in which CCC is doing this is to sponsor a series of workshops on various topics: thus far, "big data computing," "cyber-physical systems," visions for theoretical computer science, the future of robotics, and network science and engineering. CCC is actively soliciting proposals for additional workshops from members of the research community.

The "tire tracks" diagram illustrates time from concept to billion-dollar industry.



SOURCE: NATIONAL RESEARCH COUNCIL. *ASSESSMENT OF DEPARTMENT OF DEFENSE BASIC RESEARCH*. THE NATIONAL ACADEMIES PRESS, WASHINGTON, D.C. 2005.

The participants in these workshops are primarily researchers. The workshops also involve representatives of funding agencies—critical to transitioning research visions into funded programs. Often they also involve industrial participants. A recent example of success is CCC's "Big Data Computing Study Group." In late March 2008, two workshops were held in Sunnyvale, CA. The first was the "Hadoop Summit," whose goal was to build a community of users of Hadoop, an open-source version of Google's MapReduce system[1] for distributing computations across clusters of thousands of nodes. The second was the "Data-Intensive Scalable Computing Symposium," whose goal was to build a community of researchers concerned with various issues related to "big-data computing" (slides, videos, and summaries are linked from the CCC Web site; www.cra.org/ccc/). Both of these community-building exercises were successful. And, as a result of preliminary work done by the core group of organizers of this effort, Google, IBM, and Yahoo! have made large-scale clusters available to the academic community for education and research, and the National Science Foundation has announced its CluE (Cluster Exploratory) research initiative. There is no magic here—it takes dedicated individuals to make things happen. But CCC can be an enabler.

A number of other CCC activities are described on CCC's Web site, which includes descriptions of various grand challenge problems and a blog devoted to discussions of research visions for the field. More broadly, CCC is working along with other organizations to "get the word out" regarding our field. I encourage you to become engaged. Participate in the CCC research visions blog (www.cccblog.org/). Join with colleagues to propose a workshop to chart a compelling vision for future of your subfield.

Computer science has accomplished so much, and there is so much additional exciting work to do. The opportunities are truly extraordinary. It's up to us to seize these opportunities.

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