News
Stepping Up to Long-Term Research
Greg Goth

After many years of budget cuts and limelight lost to other disciplines, long-term computer science research is receiving a new, if tentative, boost. Recent government-sponsored reports have emphasized basic CS research needs and, perhaps more important, a general direction the overall effort might take. Concurrently, the US Congress has begun to demonstrate a willingness to fund some of these projects to an extent sorely lacking for several years.

“I’m more optimistic than I was even a year ago about the general trend,” says Peter Harsha, director of government affairs for the Computing Research Association, a Washington-based organization representing academic and commercial research entities. “I think there’s a growing realization both across Congress and the mission agencies that we’ve stepped away from long-term research and it’s time to recommit ourselves to it. The key is seeing if all that good talk is followed up by dollars.”

Leadership and complexity

Among the markers indicating potential change, Harsha noted the September release of a long-awaited report from the President’s Council of Advisors in Science and Technology. Leadership under Challenge: Information Technology R&D in a Competitive World (http://ostp.gov/pcast/NITRD%20Review.pdf) is the follow-up to the 1999 President’s IT Advisory Panel. Both reports called for renewed emphasis on long-term basic research in the computing sciences. However, no funding followed the 1999 report.

Still, the benefits of basic CS research are evident everywhere in Internet-based networked computing and communications. So, researchers and their advocates are talking about next-generation concepts to audiences who understand the potential power of what begins in academic labs—the decades it takes for basic research to reach the street can be well worth the wait.

One keystone report from researchers laying out the next-generation agenda is Ultra-Large-Scale Systems: The Software Challenge of the Future(http://www.sei.cmu.edu/uls). Carnegie Mellon University’s Software Engineering Institute released the ULS report in July 2006. Its lead author, Linda Northrop, says the research community’s interest in it has been worldwide. She reports 78,000 downloads of it through early August 2007 and more than 1,300 hard copies requested from the SEI’s ULS Web site.

The report calls for an entirely new approach to building networked systems, comparing them to huge real-world complex systems, such as cities and macroeconomic models. “The basic premise underlying the research agenda presented in this document,” the report says, “is that beyond certain complexity thresholds, a traditional centralized engineering perspective is no longer adequate nor can it be the primary means by which ultra-complex systems are made real. Electrical and water systems are engineered, but cities are not—although their forms are regulated by both natural and imposed constraints.”
A next-generation research manifesto

Because the US Army funded it, the ULS report has a marked defense-oriented perspective. Northrop says the authors realized that this style might put off many domestic researchers who don’t vie for defense contracts, as well as international researchers who have no interest in augmenting the US military’s capabilities. However, Northrop says Addison-Wesley will publish a less defense-oriented version that should appeal broadly to computer science researchers.

Nevertheless, even the original report is sparking global interest. Northrop says she talked with many people at the May ACM/IEEE International Conference on Software Engineering who said they had defined research programs based on it. “So from the research community,” she says, “we’re getting quite a lot of traction.”

One of the report’s coauthors, Vanderbilt University professor Douglas Schmidt, says that some people are looking at it as the researchers’ manifesto for the next generation of networked systems—a clear vision that’s been missing from the computer science community’s laments about inadequate funding.

“People like to work on reductionistic problems,” Schmidt says. “Hence, ULS-type research has been neglected in favor of nice tidy problems. But the real world is not neat and tidy. And as systems get more complex and people use computers for more and more things, they’re finding that the things people have historically studied in computer science often solve the problems that were solved five years ago.”

Conventional wisdom due for a drastic makeover

For a broader community of CS researchers—and just as important, funding organizations—to fully embrace a call for effort directed toward “blue-sky” work such as ULS research, two cornerstones of thought underlying today’s networks and computers must be drastically reconsidered.

The first arises from the way the Internet originated. It didn’t arise from a ULS-style technical vision of global ubiquity, robustness, and reliability. Rather, it emerged from the most basic of intentions—routing small packets of data from one computer to another.

Second, while the earliest champions of both packet-based Internet technology and next-generation ULS technology have been US Department of Defense officials, the overall flow of groundbreaking technology has reversed course from defense-inspired and defense-funded projects to commercial or mixed-use technologies. So, for example, the Army has funded a project to devise a commercially viable, flexible display infrastructure for future military and civilian use. The rationale behind this effort is that the technology was futuristic enough that the private sector could not invest enough in basic research by itself to gain sufficient payback in a timely manner. However, the DoD didn’t want to breed a superspecialized technology that would lead to niche manufacture of extremely expensive units with limited commercial potential.

The ULS effort could benefit from the effort to exploit new public-private funding partnerships such as the flex-display effort. The US National Science Foundation has funded Schmidt, University of Virginia researcher (and ULS report coauthor) Kevin Sullivan, and University of California at San Diego and Michigan State University researchers to plan the Center for Ultra-Large-Scale Software-Intensive Systems (ULSSIS, http://ulssis.cs.virginia.edu/) pronounced Ulysses. ULSSIS is envisioned as an NSF Industry/University Cooperative Research Center. The I/UCRC program is meant to leverage relatively small NSF investments into more substantial academic-commercial funding partnerships. Although ULSSIS hasn’t yet received official I/UCRC status, Sullivan says early interest has been encouraging; Schmidt calls the NSF seed money “the pot for the stone soup.” He says the nature of the ULS work will mandate widespread collaboration between multiple academic disciplines as well as cross-pollination of industrial and academic ideas.
Schmidt says it will take a long time to shift the popular mindset away from the Internet’s bottom-up success. The ULS research will have to start with a grand vision. Schmidt says the ante for networked systems is also higher because the world knows how vital they’ve become.

“Those guys didn’t have any intent when they started to do what ended up happening,” Schmidt says. “They were just having fun. They spent weeks and years building things that would route one packet. What we’re trying to do here is to start with a broader vision and see if we can entice the community to join us.”

Sullivan says the ULS researchers will have one advantage over the Internet’s forefathers in enticing the broader community. Specifically, the new technologies’ likely users, such as automotive-system developers, are well aware of the predicted ubiquity of the next generation’s technologies in systems such as car-to-car communications and car-to-transportation system monitoring networks. They can also see how data from the network’s edge will affect its core and vice versa.

“Many traditional engineering companies, from automobile manufacturers to healthcare to energy and RF communications companies, are already somewhere along this spectrum—understanding they’re going to become software companies,” Sullivan says. As for making research funders aware of this, he says, “If one judges by recent history, it’s going to be difficult, but it’s also essential that it happens.”

The funding begins

Despite the recent record of diminished budget support, the CRA’s Harsha points to several developments that might hearken better times for basic computer science research, including the passage of the America Competes Act (HR 2272)(http://thomas.loc.gov/cgi-bin/bdquery/z?d110:h.r.02272:), signed into law in August. Section 7024 of the new law liberalizes the boundaries of the High-Performance Computing Act of 1991; Harsha says the law essentially authorizes the doubling of research funding over the next seven years.

“From a symbolic point of view, it’s really important to have the entire Congress on record and the President on record to support these big increases,” he says. “The worrisome issue is a looming showdown between Congress and the administration on getting particular things funded, a possible veto, and the likelihood of Congress overriding that veto. So research funding may get caught up in a much larger political debate and take some collateral damage.”

However the political dance resolves itself, Harsha sees a distinct recognition of the need for more emphasis on basic sciences and expects to see a rebalancing of funding between those areas and the life sciences projects at the National Institutes of Health. The NIH biomedical research budget almost doubled from 1998 to 2003 (http://www.cra.org/govaffairs/images/FederalR&DbyAgency2.pdf), while support for other sciences stayed virtually flat.

“This became a problem even for NIH,” Harsha says, “because the rate of innovation in health sciences is being severely impacted by the fact physical sciences aren’t keeping pace.”

The stark imbalance and its results might now be paying unforeseen dividends, as researchers in many disciplines have become more aware of their codependence in a data-intensive, network-centric community. Perhaps their observations will bear fruit with funding sources that must be willing to create new avenues of multiorganizational, multidisciplinary work.

“The meta-issue here is that ULS research is almost by definition not something that can be done by one person by themselves,” Schmidt says. Nor, perhaps, could one nation’s funding resources stretch far enough to reinvent the networked-computing paradigm.

Schmidt says the ULS work might dovetail well with a more internationally friendly attitude among federal agencies. “The good news about NSF these days is they are trying to do more outreach for
international collaboration," he says. "Funding Americans to work with people from other countries, providing some travel money to explore expanding their work beyond geographic boundaries—that could be a payoff in terms of ULS work. Europeans emphasize using technology in global way, like 'green' technology and sensible mass-transit systems management, and those things all start getting into a ULS-type system."

Sullivan says the SEI report might be the precursor of a new global research consensus just as the 1968 NATO report that popularized the term “software engineering” (http://homepages.cs.ncl.ac.uk/brian.randell/NATO/nato1968.PDF) shaped global opinion of state-of-the-art technology.

"We've largely pursued a sort of engineering paradigm for software per se since then, and it might be that that needs to change to some extent," Sullivan says. "We might need to leverage ideas from social sciences, economics, ethnographic studies, and design theory which extend well beyond software engineering.

"I view our ULSIS center as the sort of place where that sort of thing can happen, with high-end academic resources plus people from industry and government, looking to establish not just a national but an international model for academic research. A model that's deeply informed by the problems being faced by the people who are actually building these systems."

**Related URLs**

- America Competes Act,(http://thomas.loc.gov/cgi-bin/bdquery/z?d110:h.r.02272:)

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