Observatoire Landau

What Is Cyberinfrastructure, and Why Do We Hear So Much about It?

By Rubin Landau, Department Editor

The Oregon summer is one of our well-kept secrets out here in the upper-left corner. It hardly ever rains, the sun shines a lot, and the temperature is cool enough to enjoy being outside, yet still sleep at night with a blanket. So why have I spent so much of the precious summer thinking about cyberinfrastructure (CI) rather than standing in a river fishing or writing a good book? As you might expect, the answer has more to do with money than good sense—namely, writing a grant proposal to pay for the creation of some building blocks in the infrastructure. Now that the proposal is floating in the bureaucratic digital ether, I feel that I should be able to provide some thoughtful reflections on CI's nature, although to be honest, it will be six months before I know if my CI vision agrees with that of the money distributors.

In my browsing for meanings of CI, the first use appears to be in 1998 by Jeffrey Hunker in **[Press briefing: http://www.fas.org/irp/news/1998/05/980522-wh3.htm]**, who was then the Director of the Critical Infrastructure Assurance Office and concerned about threats to the US. To him, the cyberinfrastructure that needed protection included the Internet, electric power systems, transportation systems, and banking and financial systems. This clearly is a broad view with all cyber-based information systems being covered, and in which CI represents the multiple and overlaying grids spread across the country, somewhat like the Visible Man's arteries, veins, and bones. And much like in a human, a breakdown in any one grid can cause widespread harm (although I keep hoping futilely for the financial grid to break down after I purchase carpets with my Visa card in some far corner of the world).

The word "cyber" itself appears to be an abbreviation of cybernetics, a term first used in its modern sense by Norbert Weiner [Wiener, Norbert, *Cybernetics, or control and communication in the animal and the machine.* Cambridge, Massachusetts: The Technology Press; New York: John Wiley & Sons, Inc., 1948] to denote the study of control processes in biological, mechanical, and electrical systems, and especially the flow of mathematical information within these systems. (The word *cyber* derives from the Greek word for governing, which I suppose is another term for control.) If we now extend this idea to include computer and information systems, and the hardware and software for them, we're coming to cyberinfrastructure. By combining cyber with the word infrastructure, I believe that CI also denotes the idea that cybersystems will be there for us to use without much thought or concern about their reliability and details (as with our highways and bridges?), and thus free us up to be our creative and original selves.

The most-used meaning of "cyberinfrastructure," at least by those of us trolling for grant support, is (surprise, surprise) that put forward by the US National Science Foundation (NSF). In 2003, the NSF took a data-centric view of CI as "the new research environments that support advanced data acquisition, data storage, data management, data integration, data mining, data visualization and other computing and information processing services over the Internet. In scientific usage, cyberinfrastructure is a technological solution to the problem of efficiently connecting data, computers, and people with the goal of enabling derivation of novel scientific theories and knowledge." [**http://www.nsf.gov/news/news_summ.jsp?cntn_id=100330]** High minded, but rather officious.

But as fashions change, so too do definitions. A more human view of CI is that given by Fran Berman, the San Diego Supercomputer Center's director: "Cyberinfrastructure is the coordinated aggregate of software, hardware, and other technologies, as well as human expertise, required to support current and future discoveries in science and engineering. The challenge of cyberinfrastructure is to integrate relevant and often disparate resources to provide a useful, usable, and enabling framework for research and discovery characterized by broad access and 'end-to-end' coordination."**[http://vis.sdsc.edu/sbe/SBE-CISE_Workshop_Intro.pdf, http://www.sdsc.edu/about/Director.html]** . This definition moves away from CI's control aspect, and doesn't seem like something we need to protect from foreign invaders.

That CI includes the people element and is needed for research and creativity might just reflect Berman's view of our modern world. However, it must be true seeing that the NSF's Blue Ribbon Advisory Panel on CI also came to the same conclusion: "Like the physical infrastructure of roads, bridges, power grids, telephone lines, and water systems that support modern society, 'cyberinfrastructure' refers to the distributed

computer, information and communication technologies combined with the personnel and integrating components that provide a long-term platform to empower the modern scientific research endeavor." **[Atkins report, http://www.nsf.gov/od/oci/reports/toc.jsp]** I like these later definitions because they make me feel that my limited efforts to improve computational science education for people are strengthening the CI, and thus building a stronger society. Indeed, the aforementioned Blue Ribbon Panel envisions us building new types of scientific and engineering knowledge environments and organizations on the CI to pursue research in new ways and with increased efficacy. Although I can't envision a world without a good book to read each night, maybe the next good book that I'll write will have to be CI-correct.

PS: Please take note of the plans to have a future issue, or maybe more, devoted to *Education in the Computational Sciences,* and the concordant call for papers. More details should be available at the SC Education Program pages, http://www.sc-education.org/.