LETTERS

The Grid Grew from Physicists' Computing Needs

The feature article by Ian Foster on "The Grid: A New Infrastructure for 21st Century Science" (PHYSICS TODAY, February 2002, page 42) presents well the structure and great potential of the Grid. At a time when government funding tends to focus on short-term returns that directly benefit society while overlooking basic physics research, Foster has reminded us that physics remains closely associated with important new, far-reaching technological developments.

I think PHYSICS TODAY missed an opportunity to deliver an important message with the publication of this fine article: Basic physics research, and basic science research in general, is often the driving force behind important developments in computing. In the European part of the world map (see Foster's figure 4), the prominent role of CERN and of high-energy laboratories in Europe is obvious. Yet CERN (or its Large Hadron Collider) is briefly mentioned twice in the article, and only for its computing demands rather than for its contributions to the field.

During the mid-1990s, when I was the adviser to the CERN director general on member state affairs, I had to rally support for the LHC among nonscientists. The expected computing technologies resulting from the LHC and the potential for broad application of those technologies were a strong selling point. I would tell my audience that each large detector must handle more than 10^{15} bytes of information per year, about a million times that contained in the human genome. This fact made an impression. At the time, given the existing technology, it was impossible to handle that amount of information. The use of CD-ROMs for storage would have required a 3-kilometer-high stack of them; processing the information would have required 50 000 PCs.

But my experience has been this: Trust the physicists. By 2005, they will have found a way to meet the computing challenge, with resulting benefits for people from many walks of life. The detector collaborations, each with close to 2000 scientists, contain a vast number of highly competent people who freely exchange information and criticism. They know that, despite limited funding, they must be able to trade ideas and information and must have a successful system for that in place by the time the machine is completed.

Now, several years later, the picture has already changed. By making the best use of improving hardware and networking, scientists can reduce the storage stack by a factor of 5, and reduce the number of computers needed for processing by even more. The Grid offers the possibility of greatly enhancing the available computing power for any specific need.

Yet the capacity that LHC scientists will need has not been reached. Current technology, when fully used, already gives a factor of 10, but new developments to increase computing capacities by another factor of 10 are needed during the few years that remain before the LHC is commissioned. The Grid will play an important role in filling this need.

I think that particle physics (and heavy basic science research) as the driving force behind computing developments cannot be overemphasized. Clearly, particle physicists are not alone in demanding new and highly efficient computing means. However, carefully planned projects in the past have often fallen short of expectations, whereas those technologies that arise spontaneously out of the computing needs of physicists have paid large dividends, usually at relatively low expense.

Other arenas are motivating increases in computing power, particularly in the US, but particle physics has a specificity of its own. Very large amounts of data must be available simultaneously to a great many users. The number of physicists working coherently on the LHC will exceed 6000, scattered worldwide. These users will need both access to information and the ability to process it. The solution to this computing challenge, once implemented, will find many other applications.

So I would like to end on a provocative note: If you want much better computing worldwide, remember to also invest in particle physics. The computing advances are likely to come faster and to be less expensive that way than through a more direct, top-down route.

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FOSTER REPLIES: I appreciated Maurice Jacob's thoughtful comments on the important role that physics and physicists often play in advancing information technology. I believe strongly in the use of challenging practical problems as drivers for IT R&D; such problems serve to focus on the real issues and provide rapid, if sometimes painful, feedback when apparently good ideas do not work. I am also convinced that, to achieve the order-of-magnitude performance improvements promised by Grids, we must engage not only discipline specialists but also computer scientists: for better or worse, it is no longer sufficient to view IT issues as secondary to the physics. For these reasons, I and many of my colleagues are so excited about current Grid projects, many of which involve genuine multidisciplinary partnerships focused on extremely challenging problems.

Jacob speaks more specifically to the important role that CERN has long played in IT. In a brief overview article, I could not discuss specific projects; with more space, I would have written at length about the plans and achievements of the CERN-led European Union DataGrid and DataTAG projects, the pioneering work at Italy's National Institute for Nuclear Physics (INFN), and other physics-focused

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Grid initiatives. (A list of project URLs can be found at http://www.mcs.anl.gov/~foster/grid-projects.) I would also have discussed the various virtual observatory projects (see PHYSICS TODAY, February 2002, page 20), and environmental data Grid efforts. I hope that Jacob's letter and my response will clarify that physics problems and physicists are indeed central to the emergence and evolution of Grid computing.

We must all hope, as Jacob suggests, that physics will continue to have the opportunity to pose IT challenges of the magnitude associated with the LHC.

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Sprites and Elves Are Seen but Seldom Quantified

I believe Earle R. Williams's article "Sprites, Elves, and Glow Discharge Tubes" in the November 2001 issue of PHYSICS TODAY (page 41) requires additional historical background. For decades, pilots have reported observations of auroralike flashes of light immediately above very large thunderstorm cells; such reports have come particularly from commercial and military pilots who have flown routes along the coast of Central America, home to some of the most severe electrical storms on the planet. Scientists have consistently dismissed these observations as everything from glare on the inside of cockpit windows to tricks played by the minds of sleep-deprived pilots on long-distance flights. Perhaps in the light of this article, some members of the scientific community will not be so quick to dismiss observations made by laypeople.

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WILLIAMS REPLIES: Eyewitness accounts often provide valuable input to scientific progress. If greater attention had been paid to eyewitness reports of transient luminosity in the middle atmosphere, progress in sprites research would no doubt have been quicker. This expectation seems particularly true given greater awareness of C. T. R. Wilson's early predictions on sprites (ref. 1 in my article).

Capps's characterization of quick dismissal by the scientific community is perhaps unjust. Many scientists simply find little to say about qualitative observations. As Lord Kelvin said, "When you measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, . . . your knowledge is of a meager and unsatisfactory kind." Ball lightning is another area in atmospheric electricity in which relatively little progress has been made, largely because good quantitative measurements are scarce.

Given the limitations on article length, I chose to concentrate on aspects of sprites research for which numbers are available and where observations agree and disagree. The earlier historical background Capps mentioned was addressed in the review article by Craig Rodger (ref. 4 in my article). Further discussion of historical observations was given in an older paper that W. A. Lyons and I wrote for the American Meteorological Society's Conference on Atmospheric Electricity in 1993.

I look forward to further discussions with Capps about the eyewitness accounts he mentions, which may not be generally available to other scientists.

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Edward Condon Remembered

In her interesting article "Edward Condon and the Cold War Politics of Loyalty" (PHYSICS TODAY, December 2001, page 35), Jessica Wang summarizes the remarkable career and political tragedies of this accomplished physicist. One of his last contributions to science and society, though, is missing.

Between 1966 and 1968, Condon headed the Colorado Project, also known as "The Scientific Study of Unidentified Flying Objects" [and Project Blue Book]. The published results of that work became known as the "Condon Report," and its most famous conclusion was: "Careful consideration of the record as it is available to us leads us to conclude that further extensive study of UFOs probably cannot be justified in the expectation that science will be advanced thereby." Much of the general public may still believe that UFOs are piloted spacecraft from alien worlds, but Condon's thorough analysis at least liberated American science from the task of pursuing this illusion.

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The article on Ed Condon taught me much I should have known about the endurance of a scientific leader in the face of political attacks. Condon was kind to me—in a completely different field—when I was the youngest assistant professor in the physics department at the University of Colorado in the mid-1960s. His legacy is the present excellence of the department and of JILA. I miss his puckish humor.

Ed used to offer me a ride in his huge Cadillac; he could barely see over the steering wheel. The first time he offered, I was reluctant, because of his reputation as a terrible driver. He explained that, since he drove a Cadillac (though admittedly secondhand), he could never be accused of being a Communist.

When he was appointed chief scientist on Project Blue Book (a US Air Force-sponsored review of evidence for UFOs), he said that he was chosen because of his history—no one could say that he was automatically biased on the side of the government.

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Jessica Wang's excellent article on Edward Condon's career and trials inspired this letter. He had an ability that may not be fully recognized but that should be mentioned in any evaluation of his career.

Condon was my adviser in graduate school. Early one morning, I entered his office to be greeted with "Bob, what's on your mind that you can admit?" I referred to an article that I did not fully understand in the latest *Physical Review*. He took his unopened copy of the *Review*, turned to the article, scanned it with amazing speed, went to the blackboard, and said, "Are you taking Robertson's course in methods of mathematical physics?" After I said "yes," he explained the article at my level of mathematics.

As we sat and talked, a senior in physics entered and apologized for