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Look in the Spaces for Tomorrow's Innovations

the science of future technology

I F YOU WANT TO KNOW WHERE THE FUTURE OF COMPUTING AND COMMU- nications is going, I suggest you first "look at the spaces." I'll explain what I mean by that, but first, recall the (in)famous predictions we find it easy to chuckle about today, including: There is a worldwide market for only a handful of 1950-era computers. And people don't want computers in their homes.

These and dozens more such predictions were made by very bright and knowledgeable people— often by leaders in computer science with access to better information about technology trends than most of us have. These predictions ought to teach us a lesson. The simplest is, of course, that predicting anything is difficult, apparently very difficult. Specifically, it seems to be difficult to predict the way technology will be used. Easy to predict are the number of bits in a RAM, the number of transistors on a die, or the density of magnetic storage. But see- ing how a bright, entrepreneurial engineer will use them or what the societal impact of that use will be—that seems to be very difficult indeed. Why?

The answer, I think, lies in the fact that when technology changes enough, it doesn't just change how we do things, but what we do. That's what's dif- ficult to think about. In my view, the predictions failed because they assumed that future uses of com- puters would be the same as the uses at the time the predictions were made. It's true that if all you want to do is compute ballistic tables, then a handful of

computers is enough. If computers are refrigerator-size, need special power and cooling, and are used for business data processing, then of course you wouldn't want one in your home. But that's not what happened. The incredible progress of technology has enabled us to use them in new, innovative ways that those making the predictions didn't anticipate.

In the spring of 1996, The Computer Science and Telecommunications Board of the National Research Council released a report "The Unpredictable Certainty," a title I think is wonderful. It happened to be a report about telecommunications, but the title really could have been used to describe many aspects of information technology. It's absolutely certain there will be dramatic changes in society because of the technology; equally unpredictable is what they will be. But, again, why?

The Interesting Stuff

Is it possible to make predictions that are better, more accurate, or at least more sensible? There are certainly sound social as well as financial reasons for trying. I don't know, of course, but I have a suspicion that, as with oriental art, we have to "look at the spaces." That is, thinking of the current uses of computers and communications as objects on a landscape, the "interesting stuff" is in the spaces between (and relating to) the objects.

For example, the World-Wide Web is an object on the landscape. Yet, magical as it seems to many now, it is certainly just a stepping-stone on the way to something else. As bandwidth and processing power increase by orders of magnitude in the next decade, new uses will emerge we haven't thought of—that are still "in the spaces" today. That's not to say the current uses will disappear; ballistic computations and data processing are still with us and will continue to be. Web browsing will be too.

But, as in oriental art and gardens, the spaces between the objects define their relationships. A full appreciation requires a look at these spaces to discover the relationships. Indeed, looking at the

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objects can be distracting and misleading, focusing on the "now," rather than the "can be."

Enlightenment Through Humanistic Scholarship

I have become quite charmed by one such "space" during the past few years—humanistic scholarship, or research in history, literature, the classics, that sort of thing. Only six years ago, if I thought about it at all, I probably would have said humanities scholars were technophobes who would be interested in word processing and not much else—I saw only blankness in the space. I now see it as one of the most dynamic opportunities in computing and a rich source for interesting problems for computer scientists and engineers. In fact, I think information technology will have greater influence on scholarship in the humanities during the next two decades than on science and engineering.

When I say this, my techie friends usually ask for an example, so I'll briefly supply two, one in history and one in literature. But first I have to say that my knowledge is derived from interacting with some truly fine scholars and having a bit of their knowledge rub off on me, so my knowledge is less than skin deep.

Consider the work of two scholars at the University of Virginia: Ed Ayers and Jerry McGann. Ed is a Civil War-era historian; Jerry is a professor of English who works in an area called the "theory of text." Both are Fellows of an Institute we created at Virginia to explore how information technology could be applied to the humanities.

Historiography—the methodology of research in history—has moved away from a focus on the "big figures" of history, like the kings and generals, toward the experience of the common person. Modern historiography is enormously facilitated by our technology.

Ayers' project, for example, is assembling detailed information on about 10,000 individuals. About 50% of these people lived in Chambersberg, Pa., at the northern end of the Shenandoah valley; the other 50% lived in Staunton, Va., at the southern end. In virtu-

ally every respect, the communities were identical, except they happened to be on opposite sides of the conflict and even fielded units that fought each other.

The written record explodes at about the time of the Civil War, so Ayers has entered birth/death records, tax records, tax maps, diaries, letters, military records, every newspaper from both communities for 20 years surrounding the war, and much, much more. Many of these items were already in the public domain but were separated by both physical location and institutional ownership. Still others were secreted in family attics, inaccessible to even the most diligent scholar. When it's all entered and linked, the result will be nothing like a traditional history book. For one thing, it won't merely lead the reader through the author's interpretation of events. For another, it will be a window on a fascinating period with the "reader" in control, able to explore and test hypotheses not anticipated by the "author."

McGann is interested in the production of what are called "critical editions," which are a way of relating the many versions of an author's work. An elaborate paper-based technology has developed among scholars to capture these differences and the relations between them. Unfortunately, the technology works only for text. It's fine for many authors, such as Mark Twain or William Wordsworth, whose output is text, but it fails for such author/artists as Gabriel Dante Rossetti or William Blake. Rossetti, for example, was a 19th-century painter and poet who painted about his poems and wrote poems about his paintings. He also happened to modify both frequently, making it hard to know which version of a poem relates to which version of its painting. While the paper technology fails, the notion of hypertextual links (extended to allow links to/from portions of images) fits the bill exquisitely.

While it's not quite as simple as this brief description suggests, several important points can be made:

- The technology is transforming the scholarship of these researchers. It isn't just that it's more convenient. Rather, the representation of and access to information allows them to organize kinds and quantities of information that weren't possible, hence to ask and answer questions about the human record that couldn't be answered before. In science and engineering, we are used to the notion that new instruments allow us to address new questions; now the same is happening in the humanities. And just as in the sciences, the enhanced ability to answer questions provokes us to ask questions we hadn't considered before.

- With both Ayers and McGann, the result is a "living document" that can be extended, corrected, commented upon, and generally enriched indefinitely. McGann expects to devote 15 years to the creation of the Rossetti archive, thereby explaining why such works traditionally are updated on a timescale of hundreds rather than tens of years. Thus, these projects are producing a new kind of vehicle and enabling a new, more continuous and incremental approach to understanding the human record.

- Ayers and McGann both illustrate a new direction for computer-based education. Most computer-assisted instruction is "automated drill." Ayers' and McGann's projects, on the other hand, are environments in which students explore, participating in the process of scholarship rather than its product. Such exploration is perhaps the most exciting and profound aspect of their work.

A hint of this kind of change is seen in the release of the *Thesaurus Lingua Graecae* on scholarship and education in the classics. This database, which now includes virtually all Greek literature from Homer through the fall of Byzantium, has enabled undergraduate participation in research; some scholars now say it allows undergraduates to do what would have been doctoral-level scholarship just a few years ago.

Lessons

Is "computational humanities" the next World-Wide Web? Is it the space to watch? Probably not. On the other hand it illustrates what I mean by "looking at the spaces." It's not an application I suspect most computer scientists have considered. But it is an important application—probably closer to what the general public will do with the emerging infrastructure than our techie applications. Finally, it is a source of exciting challenges for computer science and engineering.

Whatever is the next World-Wide Web, I'm sure it's "in the spaces." ◼

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