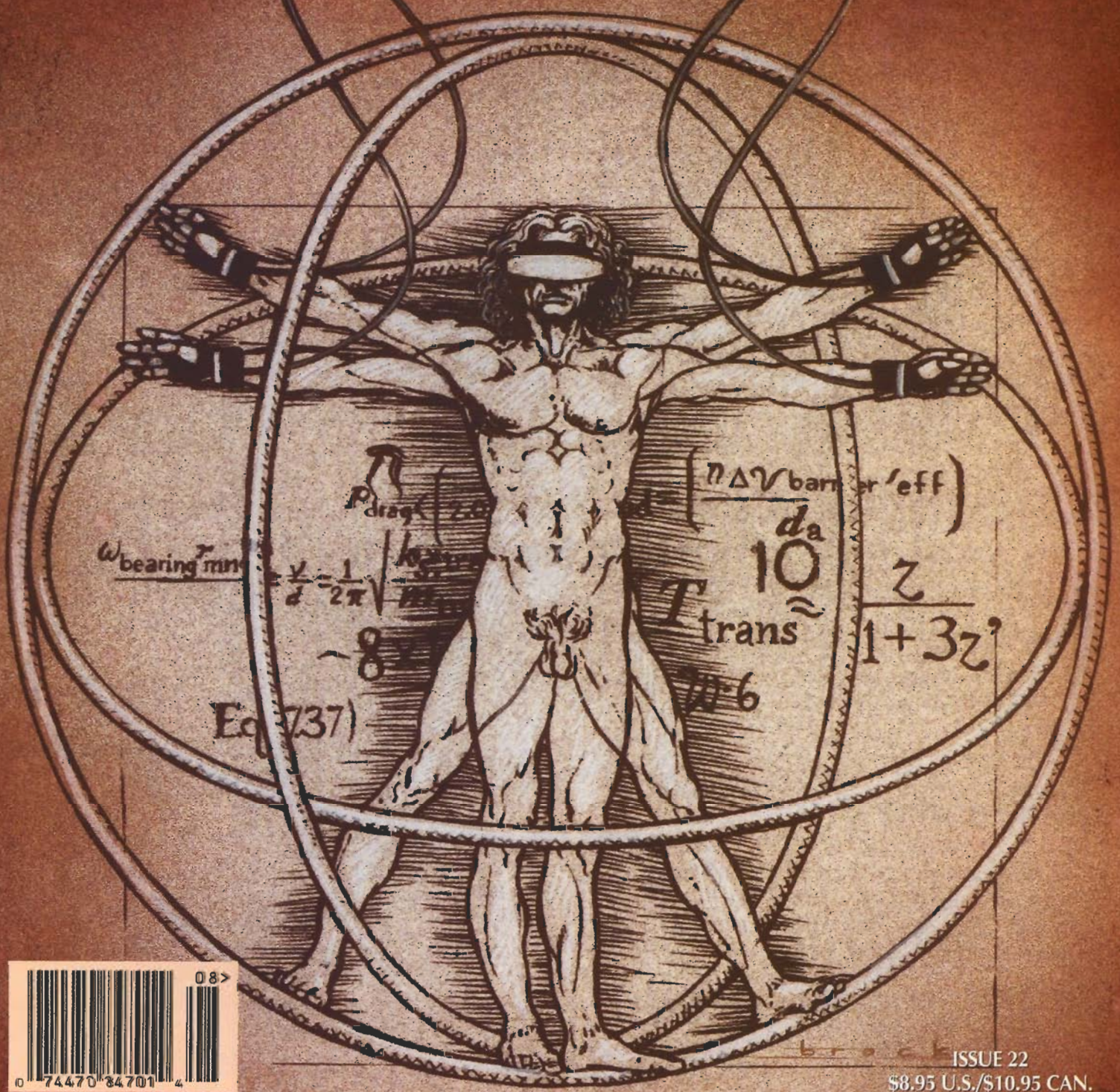
THE RED HERRING

TECHNOLOGY STRATEGY, FINANCE, & INVESTMENT.



Information provided in this issue of THE RED HERRING is based upon a combination of public data, professional insights, and street gossip overheard saving Sly's mom from the mosh pit at BFD II, chatting with Herbie Hancock and Joe Henderson at The Masonic Auditorium on Nob Hill, drinking black martinis and Shiner Bock at The Deep Ellum Cafe in Dallas, crashing motorcycles at Alden Vineyards, and hanging out with Johnny Depp and Christopher Walken on the set of "Nick of Time." Readers who use this information for investment decisions do so at their own risk.

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Bleeding Edge Technologies

THE RED HERRING

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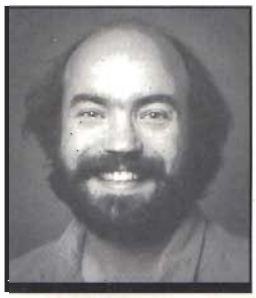
Bleeding Edge Technology—From Lab Coats to Market Caps



By MARK WEISER AND ANDY GARMAN, XEROX CORPORATION

XEROX Palo Alto Research Center (PARC) has been a cradle of Silicon Valley innovation for 25 years. The pure research done at Xerox PARC has often been on the bleeding edge, too far out to be commercially viable. The work is funded by a large multinational corporation that is increasingly focused on bringing to market some of the discoveries made at this fabled technology center.

Xerox PARC employs 300 people in two buildings on Coyote Hill Road in the Palo Alto hills. The center is very selective, and it can afford to be: researchers have turned down high salaries, founders' stock, and full professorships at top schools for the opportunity to work at Xerox PARC. Its research spans domains from atoms to anthropology, from its solid-state physics lab, which develops new laser diodes for use in printers and copiers, to the group that studies workplace-practices and their possible impact on current and future products.

The research center has made many contributions to the Xerox Corporation. The first business computer system with a graphical user interface, the Xerox Star, was based on Xerox PARC's work. The laser printer was invented there. The invention and use of Ethernet in its products helped Xerox lead the market in copiers during the 1980s. Xerox recently repositioned itself as The Document Company, since it now encompasses too many other technologies to continue being "the copier company." Read on to find out more about the integration of a research facility with big business.

AT XEROX PARC we've developed a number of bleeding edge technologies over the past 25 years. Many of them have quietly made their way into Xerox business divisions, enhancing Xerox's basic copier, printer, fax, and scanner product lines. Much better known to the public are the center's breakthrough developments in areas such as computer hardware, networking, and user interfaces, many of which have led to new industries worth billions of dollars.

Innovation includes not only technology development, but the process of bringing it to market. To that end, Xerox PARC now works in concert with Xerox Technology and Market Development to create new business opportunities through a variety of commercialization vehicles. While most PARC technology flows directly into Xerox business divisions, if a technology developed at the research center transcends a business division of Xerox, we may start a new company, put together a joint venture, partner with an existing startup, license intellectual property, or collaborate with an existing Xerox division on more focused research and development. Maximizing value sometimes means incubating a fledgling business outside the mainstream of the corporation. Then, after it has surmounted the early risk stages, we either fold it back in as a new division because it is viewed as an essential strategic component, or we spin it out of the corporation and seek liquidity through a public offering or sale, essentially taking on the role of a venture capitalist.

In building these new business vehicles (i.e., a new company, joint venture, license, or collaboration), we follow the same risk management principles as the venture capital community. We stage investments, recruit externally, compensate employees through the development of shareholder value, co-invest with third parties as required, and evaluate ourselves on the entire portfolio return—shutting down the losers and re-investing in the winners. At the same time, unlike pure startup companies, the business vehicles can draw on the financial, marketing, engineering, research, and administrative resources of a $15 billion company.

Management pundits argue that only startup companies can compete successfully in introducing radical new technology. We think otherwise. With inventive business practices and a culture that celebrates innovation, even the biggest companies can profit at the bleeding edge. And now, a quick tour of a few possible high-growth technologies.

Innovation

• The Internet, after 20 years of slow growth, has suddenly exploded. Xerox views the Internet as an important platform for delivering document services to its customers. We've invented radically new World Wide Web browsers, including one that can simultaneously display hundreds of pages and their hyperlinks using a hyperbolic projection (hyperbolic browsing is presently only being used internally). We are collaborating with five different university consortia—U.C. Santa Barbara, U.C. Berkeley, Stanford, University of

Past, Present, and Future

When we asked Xerox to write about their work in bleeding edge technologies, we were curious about certain aspects of Xerox PARC's history, particularly its almost legendary habit of missing market opportunities. *Computer Wars*, by Charles H. Ferguson and Charles R. Morris (Random House, 1993), explains that in the mid-1960s Xerox decided that the commercial computer business offered a high-growth market opportunity that would be the perfect complement to its position in copying. Xerox PARC was set up to create "the information architecture of the future." Yet apparently this marriage of research and marketing was not always happy: "Xerox's copier marketing force never adapted well to other products, and throughout the '70s and early '80s, the company repeatedly shifted its basic strategies. The people at Xerox PARC were isolated from the rest of the company, and when there was contact, too often managed to present themselves as arrogant and boorish," according to the book.

THE HERRING asked Mr. Weiser and Mr. Garman how Xerox PARC avoids having talent start their own companies with what they've developed at Xerox. Their answer is as follows:

"PARC missed some market opportunities, and also hit a few, such as laser printing (today a multibillion dollar Xerox business). PARC and its parent made some mistakes 15 years ago. They weren't fatal; we learned and moved forward.

"A lot of famous Silicon Valley entrepreneurs started at PARC: former PARC technologist Bob Metcalfe of 3Com, who commercialized Ethernet, John Warnock and Chuck Geschke of Adobe Systems, Adele Goldberg of ParcPlace Systems, and Don Scifres of Spectra-Diode Labs. Dave Liddle of Metaphor, a graphical user interface company, also benefitted from his association with the research center.

"Today, when a PARC invention isn't right for a new startup, Xerox doesn't lose the people, but joins with them to start the appropriate organization. For example, Spectra-Diode Labs was a joint venture between Xerox and Spectra Physics; LiveWorks was originally conceived as a separate company with no majority ownership; Xerox Graphic Systems is a new subdivision of Xerox; SynOptics and ParcPlace Systems were spinoffs with Xerox equity participation in exchange for PARC technology and seed funding."

The excellence of the work done there is evident, as Mr. Metcalfe attested to in a 1989 *Infoworld* interview: "My recommendation of a look at computing in the year 2000 is to go visit PARC today."

Michigan, and Cornell—to develop new digital library technologies.

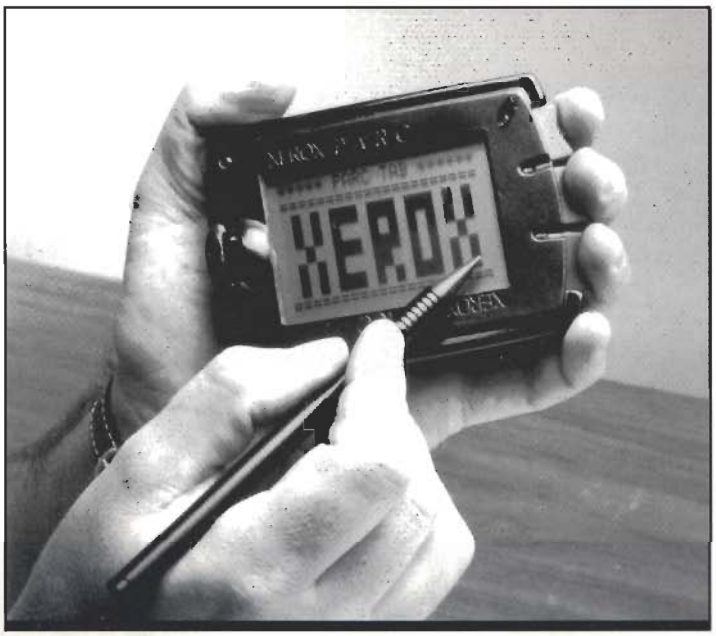
At Xerox PARC we are addressing many different Internet issues, among them ease of access and delivery of services. A key technical issue we're attacking along multiple fronts is the real-time delivery of complex information. Our Network Video software was the first videoconferencing tool on the Internet, setting the example for how to multicast (Internet-speak for selectively broadcasting) video. It is the most widely used Internet video tool today, and we have started licensing it to a few key partners in Internet multimedia products (watch for an announcement later this year). The basic infrastructure for all Internet multicasting, the Multicast Backbone, or MBONE, was developed by Xerox PARC researcher Steve Deering. MBONE work today is also being done by Professor Deborah Estrin at the University of Southern California, and by Professor Dave Clark at MIT. MBONE technology lets the Internet act as a selective broadcast medium. It has an unlimited number of channels carrying real-time audio and video material, and anyone with MBONE-capable software and an MBONE Internet connection can tune into these channels and watch whatever is on them. MBONE may be the technology that leads the world of commercial broadcasting beyond 500 channels to 5 billion channels—one channel per person. Today the MBONE is primarily used for special event broadcasting; the one regular show is by rock band Severe Tire Damage (every Wednesday at 9 P.M. PST).

The following Web site has more information: http://www.ubiq.com/std/band.html.

• Multimedia on everybody's desktop PC is only a year away, as it has been for years. Xerox PARC works on many aspects of multimedia, with a particular focus on its use for collaboration in the workplace. In the mid-'80s the center set up a lab in Oregon which has a virtual presence at Xerox PARC, using 20 continuously broadcasting cameras and microphones. Today there are three independent multimedia networks at Xerox PARC: an analog network, a high-speed Asynchronous Transfer Mode (ATM) network, and a medium-speed multicast network. By developing tools for all of them, PARC's researchers understand the limitations and advantages of each, and are learning how to use them in concert.

• Xerox PARC focuses on multimedia as a tool to help people connect to one another. The members of PARC's Jupiter project are developing a collaborative multimedia environment, in which a simple scripting language lets any user create dynamic objects and virtual rooms for interaction. Jupiter sends 50 or more simultaneous video and audio connections to every desktop, creating the atmosphere of the virtual coffeepot. ("Around the coffeepot" has been identified by our anthropologists as the most creative place in an office.) Jupiter is based on Multi-User-Dimension (MUD) technology, which is also being used in bleeding edge research at MIT's Media Lab and at Interval Research in Palo Alto. MUD technology is the basis of a new startup company based in San Francisco called Worlds Incorporated.

• Nanotechnology is the construction of machines from individual atoms. Commercial applications of nanotechnology are years away. Nanotechnology is in such an early phase that no one is yet developing specific applications, only speculative ones. Some typical applications mentioned by various nanotechnology experts are: precision manufacturing, low-power computing, precision drug-delivery into the body, and precision repair of damaged tissues. Just as Xerox PARC was a leader in the development of the first silicon design tools, it now invests in the development of Computer-Aided-Nanotech tools. Nanotech design requires the precise specification of millions of tiny pieces in 3D, and as yet without real process or design rules. Researcher Ralph Merkle is developing chemically-correct modeling



Ubiquitous Computing–Phase I: PARC's Tab

systems that allow the nano-designers to lay out and simulate stable crystalline carbon structures. He works with researchers at Xerox's chemical engineering research facility in Toronto, to investigate the potential of nanotechnology for creating new materials.

Computers as Quiet Servants

Greg Riker of Microsoft says that technology turns everyone into a superhero. In our cars we have the strength of a hundred horses. Our spreadsheets emulate hundreds of perfectly coordinated clerks. The written or printed word gives each of us the memory of a thousand Homers. One key feature of the best technologies is that, after a bit of training, we are able to use them with little or no effort. An effortless technology, like your car's "user interface," frees your conscious mind for more important tasks, such as picking the best route, solving a tough business problem, or explaining on the car phone to a VC why your latest startup deal is a slam dunk.

Technologies in their early days go through a period of glorification. At the beginning of this century electricity was touted for everything from curing cancer to finding a mate. But the real age of electricity dawned in the 1930s, when homes were first remodeled with electrical outlets, and electricity receded to the position of quiet and unobtrusive servant. Computers today are still loud and rambunctious kids, and many of us have definite love/hate relationships with them. But as computers become "quiet servants," the true age of the computer will begin. The technologies to watch are not those that are the most exciting or dramatic. For the coming age of computing, the important technologies are those that get the computer out of sight and out of mind. People will want and need hundreds of unobtrusive computers.

A long-term theme of our research is the creation of effortless, unconsciously effective technology. The mouse-and-windows interface that Xerox PARC researchers developed in the 1970s was the first fruit of attempts to integrate the machine with the person. But if you have ever wasted time at your PC trying to find "the window that was just there a minute ago," you know there's a long way to go. Apple Fellow Don Norman is also working on this problem, which he describes in his book *Things That Make Us Smart* (Addison-Wesley, 1993). The next few sections describe some core technologies for the age of the unobtrusive ubiquitous computer.

Beyond Icons and Windows—Using the Mind's Eye

We are swamped by online information, more and more of it, easily available through faster and cheaper hardware. How do you browse, navigate, retrieve, store, manipulate, and understand really large amounts of information?

Several years ago researcher Stu Card launched a research program to design a new kind of computer interface that would significantly leverage the tacit powers of human perception. As a psychologist, Stu knew that large parts of the brain perform hundreds of millions of high-speed parallel computations and correlations every second while we see the world around us. This processing is not analytical, but perceptive; it is about directly and effortlessly *seeing* and *recognizing* things. In other words, we do cognition (thinking) with what was formerly pigeon-holed as perception. A truly effortless computer interface would need to move beyond letters and words as the only way to communicate.

The result of this research was a set of tools and techniques that display information in ways that our brains tacitly organize for us. The Information Visualizer (IV) seems to directly infuse information from display to brain. One significant technique is the use of 3D animation to preserve object constancy. In IV interfaces you never feel lost, because on-screen objects behave enough like real objects to make your brain unconsciously track and remember each of them. A successor to old graphical user interfaces is evolving; but only by experiencing it can you get its full impact. Other places to look for bleeding edge user interfaces are Professor Randy Pausch's lab at the University of Virginia, David Kurlander's lab at Microsoft Research, and Dr. Beth Mynatt's lab at the Georgia Tech University. All of these places are working from the IV's point of view that perceptual processing can be leveraged to improve cognition in user interfaces.

Xerox PARC's patented techniques are bringing business value in a number of ways. Xerox is already selling Visual Recall, a shrink-wrapped PC document management product based on the Information Visualizer. In the long run the IV techniques will become part of every Xerox product that has (and what product doesn't?) a user interface. Xerox PARC is actively licensing and partnering the IV system to build new markets and business synergies company to company.

Ubiquitous Computing

The IV project is limited to what can be done with screen, keyboard, and mouse. Another project at Xerox PARC is aimed at eliminating these limitations in the computer of the future. The goal of ubiquitous computing at the research center is to develop new kinds of computers and computer peripherals that make computers and information fit naturally and effortlessly into everyday life. By developing completely new interaction systems, ubiquitous computing is creating the possibility of using even more of our tacit (perceptive, processing, and cognitive) human skills.

Phase I of ubiquitous computing work at Xerox PARC has now been completed. It consisted of building and using three new styles of devices: the Board, the Pad, and the Tab. The Board is the foundation of Xerox's new LiveBoard business, described below. The Pad, a book-sized computer, was a very useful platform for developing new software and wireless hardware that Xerox is now licensing. It was also useful in revealing to us the limitations of current battery, processor, display, and wireless technologies. Two years ago we ended the Pad research project and launched a number of small projects to crack some key problems in these underlying technologies. And then there is the Tab project.

The Tab is a true palmtop, measuring 2.5 x 3.5 x 0.5 inches and weighing only 7 ounces—including batteries. Although it has stand-alone note-taking and file-browsing capabilities, its main use is as a wireless helper for office tasks. Its "weather" button contacts the Internet and in seconds downloads a weather report for your location. Its "email" button lets you scan the most important e-mail from your office PC, and reply or save as necessary. Forty other applications for it have also been tested—some of them are still in use, from others we learned and moved on, and we are now developing more applications. The Tab fits in one hand, and so can be used while driving, drinking coffee, taking notes, etc. Far more than a PDA, we see the Tab as the doorway to a new era of tacit effectiveness. Ubiquitous computing has spread to research groups at a number of universities, such as those of Professor Brian Bershad of the University of Washington, Professor Randy Katz of U.C. Berkeley, and Professor Mary Baker of Stanford. Their projects are mostly focused on the subset of ubiquitous computing called mobile computing, which is the problem of keeping laptop computers fully or partially networked while on the move, using wireless technology. From what was learned in phase I of ubiquitous computing, Xerox PARC is now engaged in a number of ubiquitous computing phase II initiatives, including several research projects and joint technology efforts with Xerox product divisions. PARC is also sponsoring the construction of a new organization to design and market a line of effortless productivity tools. This organization, tentatively called Tacit Dimensions, is now prototyping devices and writing its business plan.

The Electronic Meeting

People spend a lot of time in meetings. They talk, they present, they collaborate, they solve problems. On rare occasions the people involved in a meeting get bored, but somehow a profound sociobiological need is felt to assemble and be with one another. In a company as large and dispersed as Xerox, the problem is the people we want to be with are often in places like London, Tokyo, and Rochester. We don't necessarily care to travel to these places every week.

One answer to the dilemma is transporter technology. Unfortunately, discretion must preclude our mentioning Xerox PARC's work in this area. However, we can talk about the next best thing, the LiveBoard. This technology offers a level of group collaboration which is very natural, but also uses the full power of networked computing and videoconferencing. It evolved from a decade of research at the intersection of ubiquitous computing, studies of work-practices, the development of natural user interfaces, and liquid crystal displays.

LiveBoards are large devices with enormous (67" diagonal) displays that you can access or write on from across the room with special electronic pens. Application software allows you to use them like whiteboards, but whiteboards with proprietary list processing and object management. While one workgroup is brainstorming in Palo Alto, another group in New York collaborates on a remote LiveBoard as if they were in the same room. Real-time videoconferencing runs in a window on the same screen. It runs Windows, so groupware or other favorite applications can run on it as well. LiveBoard is one example of the new area of collaborative computing in which Irene Grief of Lotus Research and Professor Tom Malone of the MIT Sloan School are leading researchers.

Xerox has taken LiveBoard to market. As the technology did not fit the existing Xerox business models, manufacturing competencies, or distribution channels, LiveWorks, a new subsidiary in San Jose, CA, has been incorporated to incubate the idea in a startup environment, and is already shipping its second generation products.

A Better Way to View the World

It wasn't so long ago that we were perfectly content with our Mac SE and its four-inch-high monochrome display. Now the CRTs we use are so large that there's little or no room for the keyboard on our desks. Despite their "millions of colors" and massive viewing area, these displays are not pleasant to read for periods of time longer than 10 minutes. Xerox PARC is in competition with a cadre of other companies whose display work is also in the development phase. These include Silicon Video, ColoRay Display, FED Corp., Sarif, Plasmaco, Pixel, Kent Display, and others. The research center has built flat-panel displays with image quality better than that of 300 dpi laser printouts, and is working on the possibility of locating part of a computer's processing powers right on the display surface. As a greater degree of computing value migrates onto the display itself, control of the display may mean control of the central processor. This may radically change the design of future computers and the companies that build them.

Display research is also popular outside of Xerox PARC. Some new flat-panel technologies to watch are ferroelectric displays, polymer-stabilized cholesteric displays, liquid-dispersed polymer displays, field-emission displays, and Texas Instruments' deformable mirror display. Each seeks either a dramatic improvement in image quality, lower power consumption, lower cost, or some combination.

We admit there are a few bugs yet to be worked out. That's the nature of all bleeding edge technologies. What are the consequences of success? The possibility of selling millions of palmtops or really easy-to-read displays, revolutionizing user interfaces or making cross-country meetings as productive as a local brainstorm in the coffee corner. Wherever technology takes the document, Xerox will be there.

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Opinions are those of Mark or Andy, not necessarily those of Xerox.