The Bionic Organization

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For the past century, no economic force has been more effective in creating and destroying businesses than the accelerating pace of technological innovation. To thrive, indeed to survive, companies must be able to quickly and effectively capitalize on the opportunities created by new technologies. The dustbin of history, however, is full of companies that rushed to embrace a technology only to find that they did not understand how that technology would be used, underestimated barriers to adoption, or failed to foresee unintended consequences. At a recent meeting of Cap Gemini Ernst & Young's Technology Advisory Board, a discussion of emerging technologies dwelled on these very points. Humans are key to the success or failure of technologies, and a better understanding of the business and strategic opportunities created by technology can only come through an improved grasp of the emotional, cognitive, psychological, and social factors that surround how, and if, humans use tools.

We Have the Technology

Most analysis of technology mentions Moore's Law, the observation that the density of transistors on chips, and thus the processing power available, doubles every 18 months. A lesser-known but equally important law is known as Amdahl's Law, named after IBM engineer Gene Amdahl. Amdahl's Law states that as you speed up a single stage of a process, the overall improvement is limited by that stage's share of the total execution time. For example, if a stage consumes 20 percent of the total time, doubling the speed of that stage only saves 10 percent overall. In other

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words, solving problems in one part of a system just makes other problems look bigger.

Both of these forces are at work in technology today. As Moore's Law and similar trends relentlessly improve processing speed and storage capacity, other problems emerge as the limits to functionality. Like an ocean tide receding, heretofore unseen shoals become revealed. An obvious example is battery capacity: As portable computers such as laptops and palmtops become more and more popular, the need for long-lived batteries becomes far more important, arguably more important than processing speed. And yet a laptop now runs for about two hours, the same as some laptops five years ago—a far cry from Moore's Law. Similarly, while bandwidth delivery technology has improved immensely, the cost of usable bandwidth is actually increasing. Consider that at current prices, over the three-year life span of a typical computer, you may spend more money on broadband access ($1,800 to $3,000) than on the hardware (which could be well under $1,000).

The most challenging issues, however, are those tied to cognition and communication. It's these human issues that must be overcome to make technology, especially software, more effective and useful. Information technology particularly is increasingly about enabling groups of humans, not just individuals, to work more effectively. Unfortunately, the human brain doesn't follow Moore's Law, and our imperfect brains and, worse, imperfect understanding of our brains, are both barriers to making great strides. This affects issues ranging from user interface design and manageability, to increasingly important features like security and reliability. A key insight is that an enterprisewide service, such as security, is a process that involves both technology and people, and effective solutions must factor in the strengths, weaknesses, and interactions of both elements.

We Have the Capability

The Web would change everything, we were told. As the economy shifted to knowledge-based production, the Web and other pieces of networked software were supposed to revolutionize the way enterprises learned, collaborated, and took action. It didn't turn out to be so simple. Years can pass between the invention of a technology and its mass deployment. Even when a technology is actually deployed, it may not be used or may be used incorrectly.

There's technology, and then there's technology adoption. "The Internet took 20 years to get ready for overnight success," pointed out Alan Kay. There's a lag, sometimes a lengthy one, between the invention of a technology and when it becomes widely adopted. This lag can be driven by many factors. One factor is simply the cost and time necessary for the rollout: This is at least one important reason why broadband deployment has run so very slowly. Even installing DSL as fast as possible, it will be many years before everyone can be connected. Even when a technology is widely available, however, that does not mean that people, even in a corporate environment, will embrace it.

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While it is true that the accelerating pace of technology has been instrumental in creating and destroying businesses for the past century, it is the human element—the ability to understand and optimize technology—that holds the key to success or failure. Human issues must be overcome to fully realize the potential of technology. The most challenging issues—human cognition and communication—need to be taken into account as more technology becomes about enabling groups of humans to work more efficiently together.

abstract

A dramatic and familiar example of this is knowledge management. Over the past years, many companies launched, with great fanfare, large knowledge management portals, only to see the knowledge in them decay in usefulness over time as resources get diverted. Increasingly, employees use simple e-mail more often than expensive and complex solutions as a way to exchange knowledge.

What's so great about e-mail? You're using it anyway, so it doesn't represent a new thing to learn or remember to do. Your social network is built in, since the people you know best and feel more comfortable interacting with are the ones in your address book and your inbox. And finally, e-mail's free-form looseness provides a low-overhead way to send a quick note or attach a file. Contrast this to the extra effort you must put in to use heavier-duty systems that have lengthy forms and descriptions.

People—and organizations—generally do the thing that makes the most sense, given their situation and assumptions. Adoption can be influenced by people's perception of the value of the new application, as well as by incentives (or punishments) to encourage use. But we shouldn't fight against activities like the use of e-mail as a knowledge-sharing tool; instead, we must understand and embrace the user's point of view.

Organizational barriers can also limit the value of technologies. Clay Shirky told a story of a bookstore chain that used a data-mining system to monitor how visitors were using its website. Analysis of the data indicated that users were ignoring the editorial content. When confronted with this fact, senior management rejected the finding, insisting that editorial content was how they differentiated themselves. The problem wasn't the technology, but the organizational willingness to respond to the results. The situation isn't hopeless, however. Usama Fayyad countered with a story of a national upscale department store chain. Suddenly, many visitors to their website were entering "navel ring" into the search box. This was puzzling, since the store offered no such product. Looking into it, they discovered that a model in one of their advertisements happened to be wearing one. Within three days, the chain began stocking similar navel rings in their stores and online.

We Can Rebuild It

The IT department's ancestry was the white lab-coated priesthood that tended the mainframe, often the company's sole computer, in a glass-windowed but otherwise inaccessible room. Computers were expensive and difficult to operate, and using them required a highly trained staff.

Today, the IT department faces just the opposite challenge: ubiquitous access to technology, with employees able to install new applications or make changes with little or no oversight. IT managers are sometimes considered to have done a good job if they have only avoided disaster. This drives a fundamental conservatism; if nothing new is introduced, then perhaps the environment can be controlled and nothing will go wrong. This is not to beat up on IT managers; they are, after all, doing exactly the right

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thing, considering how their performance is measured. And yet this mindset prohibits the most valuable aspects of widely distributed computer and connected assets: wide-ranging exploration, experimentation with new applications and tools and languages, and distributed learning as many employees find new ways to use tools.

The irony is that the killer app of the computer isn't really a single application, but the plasticity of the computer. That is, the ability to reform itself, to be able to run new applications, to change the way it works. IT departments that insist on a standard load-set, with dire consequences to employees that deviate, eliminate much of this plasticity. And yet that plasticity is an ingredient in the organization's ability to adapt to new circumstances and expand its capabilities.

The value of plasticity isn't always easy to see. When Alan Kay and his team at Xerox PARC demonstrated the prototype of the Alto, the first graphic interface-driven computer, to Xerox executives, their response was "what's its application?" The researchers' response was that it wasn't any one application, it was the very ability to run any application. "Yes," the executives replied, "but what's its application?" Eventually, Xerox decided to commercialize a single-application word processor instead of the Alto. It was clear to them what its application was.

Furthermore, taking advantage of plasticity isn't without cost. It requires a good deal more education on the part of users; as yet, no software interface offers an intuitive user interface for any but the most superficial plasticity. Indeed, the more a software user interface offers ease of use, the harder plasticity becomes. Another cost is that with increased customization, different users may in effect be using different applications, reducing economies of scale, and building barriers to knowledge transfer.

These dilemmas imply a powerful, new potential role for the IT department. Its role would be to respond to, in fact support, these two antithetical forces: the need for users to explore and customize, and the need for corporatewide efficiencies and a shared language. The way to do this is to shift focus away from maintaining applications, toward promoting standards and protocols, promote user education (not merely training), and package and offer centralized capabilities as services, not as applications. Only as a second-order concern should IT departments "clean up" after users, optimizing and standardizing those applications that the users adopt. Finally, the IT department can serve as ambassadors to other enterprises, meeting the wider need for common vocabularies and shared protocols and taking advantage of opportunities for collaboration and commerce in services.

IT departments specifically and technology vendors in general need to improve their insight into users' language. Like the e-mail example earlier, users have a specific set of needs and patterns of behavior that cannot be changed on demand. Successful applications must start by using the user's existing language and assumptions. Yes, new languages and behaviors

can be introduced, but only by providing pathways to users to migrate from the old to the new. One way to do this is to encourage the gradual adoption of new behavior, in sharp contrast to existing interfaces that generally make it difficult to find out about unused functionality, much less include it in a limited repertoire of knowledge without a great deal of training or a drastic change in usage behavior. Meeting these challenges will be necessary for any software applications any more complicated, feature-rich, or sophisticated than those we have today.

Better . . . Stronger . . . Faster

We asked the members of the board what they thought the interesting new features would be in technology in the next few years. One danger in predicting the future is assuming that the whole world is like you. Although we try to take a global point of view, the fact remains that we're living in North America, and it's hard to avoid making invisible assumptions. How will electronic technology be adopted in China, for example, or the Middle East? Will it be used the same way in rural India as it is in Silicon Valley? These questions can really only be answered with time, and yet it does seem that if you look at adoption and penetration curves, different regions of the world begin to look pretty similar, only starting at different times.

This isn't to say that technology is used the same everywhere, of course, or even that North America is always ahead of the pack. Certainly, the northern European and Japanese markets have embraced wireless telephony service faster and more firmly than have Americans. Similarly, the huge success of "texting," or Short Messaging Service, in Southeast Asia and Japan, has been largely ignored in the U.S. market. These differences are results of many factors, including different regulatory schemes, existing fare structures on telecommunication, and social norms (such as the acceptability of speaking into a phone in a public place such as a subway car).

Yet another difficulty in making predictions relates to what seems to be a real difference in the usage patterns between generations. Those over 30 are, in general, unlikely to have used Napster or instant messaging. For the under-30 crowd, these applications are a standard part of life.

With those caveats, the board discussed a number of technology trends from the near to the distant future, including the arrival of consumer networks, advances in user interface design, and the establishment of biological models of computing.

Consumer devices are nothing new, but with the proliferation of digital media available, the ability for these devices to be able to communicate is becoming an important feature. At the same time, the availability of wireless home networking means that nest of cables connecting stereos, DVD players, computers, cable boxes, etc., may go away. Using this network, the output from any box can be routed to any other device in the house. Entertainment isn't the only application; telephones, security, environmental control may all work with this system. Furthermore, the technology isn't limited to the house; the no-

wires, many-device features make this extremely attractive for automobiles as well.

There hasn't really been a significant advance in user interface design for software since the now-familiar overlapping windows interface. The progress remaining to be made is not so much around ease of use, but in the ability to augment the effectiveness and productivity of the user. With the increasing amount of information easily available, the challenge is to improve the user's attention, focus, and short-term memory and to do so with appropriate levels of intrusiveness. The one place where there is a great deal of experimentation and innovation in user interfaces is in gaming, and clues from this space may provide hints of the steps forward.

Farthest out, but potentially with the greatest impact, is the advent of biological models for computing. Today, computation is thought of as a mechanical process, more akin to engineering than neuroscience. A number of software researchers, however, believe that by borrowing techniques and organizational principles from biology, they can make software that is more adaptive, robust, and better suited for human applications with all their messiness. There are plenty of early signs of this, including neural nets, genetic algorithms, digital immune systems, and self-healing routing networks. And yet these techniques often borrow only a mechanism, without changing some of the fundamental assumptions and architectures found in software today.

The Six-Million Dollar Idea

It's actually old hat for consultants to say that you must consider culture and process as well as technology. What's new in this discussion is an acknowledgement that it's not enough to say that you'll shape the people to fit a new technology. In the past, the assumption has been that it is in fact possible to get people to use a new technology if only you can provide the right training, incentives, punishments, or management.

But the discussion of the board delivers quite a different message: that there are kinds of human behaviors that aren't amenable to change, and that it's better to alter the technology to fit human needs. The late Michael Dertouzos observed in his last book, *The Unfinished Revolution*, that all too often, humans are at the service of computers, rather than the much more desirable opposite. To take full advantage of new technologies, to really enable the widest range of possibilities opened up by innovation, we must make sure that technologies aren't designed in isolation from their eventual users; technology ought to help us, to shore up our weak points, and to magnify our strong points. Without ignoring or dismissing our all-too-real human limitations, technology ought to make us better at being human.

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