Where Have All the Computers Gone?

The following document arrived at the offices of *Technology Review* in a time capsule dated 2020. It purports to be a history of computers written by computer scientist-turned-historian John Seely Brown. In the late 20th century, Dr. Brown served as director of Xerox Corporation's Palo Alto Research Center.

ILLUSTRATION BY JAMES STEINBERG

THE HISTORY OF COMPUTERS is actually quite simple. In the beginning there were no computers. Then there were computers. And then there were none again. Between the second and the third stage, they simply disappeared. They didn't go away completely. First they faded into the background. Then they actually merged with the background.

These different stages of computing came to be known in terms of their central motifs: The initial stage after they emerged from the back rooms into the public was the era of personal computing, which spanned the 1980s and early 1990s. With the advent of the Internet and the World Wide Web, this era seamlessly became the age of social computing, sometimes called ubiquitous computing, which began in the mid-1990s and lasted some two decades. This age was characterized by millions of computers, information appliances and storage devices that were interconnected—creating a vast information medium that supported all kinds of communities of interest. This new medium offered access to nearly any information residing anyplace in the world.

Roughly 15 years into the 21st century, the social computing stage morphed into the period called ecological or symbiotic computing. Structural matter (atoms) and computing (bits) became inseparable. Zillions of sensors, effectors and logical elements (made of organic and inorganic materials) were interconnected via wireless, peer-to-peer technologies, producing smart, malleable stuff used to build smart appliances, buildings, roads and more. It was during this era that computers disappeared. In their place, nearly every physical artifact harbored some computationally based brainpower that helped it know where it was, what was near it, when it was moved and so on. In a way, the inorganic world took on organic properties, using computing to transparently modulate responses to the environment.

But how did this come to be? During the personal computing stage, computers became increasingly powerful, but they also became harder to use. Moore's Law, stating that computing power would double every 18 months, seemed to hold for hardware. But robust software never could keep up. The result was that personal computers remained hard to use. The graphical user interfaces of the 1980s, at least, made systems somewhat manageable. But even that degree of usability faded in the second era of computing, when designers tried to extend this interface motif to navigating the vast information and document spaces of the Web. Those who surfed the Net all day long just ended up feeling disoriented or lost. More casual users felt overwhelmed with the volumes of irrelevant information given them by their intelligent agents, or "bots" (as these were often called at the turn of the 21st century).

Eventually the Web became a jungle of information pathways with no cues to help folks to their destinations, much like the center of a megacity without reliable signs or guides. Urban architects and social theorists were called on to help technologists see the resources that lay latent in the social and physical context. Humans, it was pointed out, used the context around objects and events to navigate the world and get things done. For example, they found out what was worth reading when a friend recommended a book or when they heard about an important article at work.

It turned out that interaction with other people was the key. Humans wanted technology to help them keep better connected to each other and to enhance their awareness of events around them. But they didn't want to have to *attend* to every little thing; all they wanted was a

virtual awareness that would take place subconsciously, much like how the visual system works in the physical world.

About the same time, devices such as laptops, pagers, phones and Personal Digital Assistants (PDAs) shrank so much that an alternative to the keyboard was necessary. Speech input helped, but then a major shift occurred. Computational devices started to have sensors, accelerometers and miniature Global Positioning Systems built into them. Such units let the device know where it was and what was happening. And as things shrank further—leading to "zero volume" devices—users came to know even more about their surroundings. Furthermore, people could interact with these devices using the same gestures and other practices they already used to communicate with each other. Even a person's key chain or PDA could interpret gestures of waving, tilting, squeezing and shaking as its owner interacted with it. For instance, users would tilt the device to scroll through a Web page, shake it to erase something and squeeze it to select an item, much like a mouse click. It all seemed so natural, taking on the properties of an animated conversation. The interface became transparent starting around the turn of the century, and by 2005 such interfaces were everywhere.

Although embedding these sensors and primitive effectors into appliances was first done to enable people to interact with physically shrinking devices, a more surprising use of these innovations emerged, eventually leading to the era of ecological computing. In this era, in addition to building sensors, accelerometers and effectors into devices, designers began putting them in the environment. Literally millions of these items were placed into road surfaces so that a highway could sense the flow of traffic and then communicate that information along its surface.

Thus today, cars are aware of traffic patterns around them and use that awareness to route themselves accordingly. This helps avoid congestion and with it pollution. In similar ways, sensors in office buildings, houses and factories respond in subtle but effective ways to minimize detrimental effects and harmonize human activity with the environment. Indeed, through computing, our environment has been made aware of itself, giving rise to the era of ecological or symbiotic computing.

As we now look back we breathe a sigh of relief—for the technological "road ahead" was not nearly as straight as Bill Gates portrayed in his classic 1995 book. Indeed, a profound wake-up call was issued a short while later by Bill Joy, who, like many futurists before him, painted a one-sided dystopian view of nanocomputers and robots taking over the world and enslaving mankind. It's true that technology remains problematic. But those who believed in technological determinism were again proved wrong. Society responded, the public became better educated about the perils of radical new technologies, and new institutions emerged to help mediate the dialogue between the utopian and dystopian views. This co-evolution between society and technology may not have come as quickly as some wished. Nonetheless, it occurred in a way that forced the technological world to become less arrogant and more humble.

John Seely Brown is chief scientist of Xerox and chief innovation officer at 12 Entrepreneuring. He is co-author of The Social Life of Information *(Harvard Business School Press, 2000).*