



TERRY MIURA

Gordon Bell

The Body Electric

the human connection

BY 2047, ONE CAN IMAGINE A BODY-NETWORKED, ON-BOARD assistant—a guardian angel that can capture and retrieve everything we hear, read, and see. It could have as much memory and processing power as its master, that is 1,000 million-million operations per second, (one petaops) and a memory of 10 terabytes [3].

Content and all electronically encodable information will be in cyberspace¹ [1]! Computers are predicted to be at least 100,000 times more powerful. If hardware (such as semiconductors, magnetic memories, and fiber optics) continues to evolve at the annual factor of 1.60 rate we know as Moore's Law, then computers that are 10 billion times more powerful will exist! Zero cost, communicating computers will just be everywhere, embedded in everything from phones, light switches, motors, buildings, and highways to all seeing, all changing pictures that can converse with us. They'll be the eyes and ears for the blind and deaf, know exactly where they are, and be able to drive vehicles. The only limits to cyberization are our networks and our ability to interface computers with the various parts of the physical world through sensor/actuators consisting of direct connections, voice, gestures, and so on.

Driven by a quest for knowledge and the econom-



ics of new industry formation and efficiency, cyberization is inevitable. Since computers support, supplement, and often substitute for (supplant) other information processors, including humans, cyberization will again completely change work. Scientists, engineers, and entrepreneurs are driven to continue to “just do it”—that is, progress to realize the vision. No one is frustrated or held back by those who use “hope, policy, and time” as their tools (like bureaucrats and politicians). Progress has to invent the work that satisfies a human need and fuels the world economy so that civilization is enriched and not destroyed. However, concern over displacement has been with us with each technological revolution and new *work* always seems to be created with new opportunities in a fashion that was never predicted.

Will Cyberspace Create a Half-Full or Half-Empty Glass?

In the short term, all the world's citizens will be better off in the shift from bits to atoms as cyberspace is created and, in some cases, replaces physical space or geography as an advantage. With cyberspace there are

¹Cyberspace is the platform and network infrastructure including all communications, video, and computing devices. Cyberization is the encoding, transmission, and processing of “state” information about physical objects including humans, buildings, processes, and networks such as finance, transportation, and energy.

no geographic barriers to entry. Intellectual property can be created anywhere. The shift is characterized by titles like: “The End or Death of x” where x=work, leisure, geography, copyrights, intellectual property, money, paper, an industry, economies, or whatever. As computer engineers and scientists, the challenge—and the answer—has to be the creation of better, expanding environments.

What about bits economy? By shifting information of all kinds from atoms to bits, some of the friction (a.k.a people who collect, manufacture, and distribute physical information such as books, CDs, newspapers, reports, and videotapes) is removed. In the U.S. economy, for example, almost \$250 billion is spent on plain information, often in a physical form for fax, radio, printed media, telephony, and television. These industries are already being transformed in a bits world.

The second, much larger wave extends to financial transactions such as banking, brokerage, insurance, and realty. Finally, human-to-computer translators that process catalog and other sales, make travel arrangements, and conduct other transactions will be affected unless they add value. Given these inevitable shifts one has to wonder what becomes of the distributors and translators? Will they end up paying for the content and services that cyberspace will supply?

What about an atoms economy? Most of the world's economy operates in an atoms-based world that cares for, clothes, feeds, houses, and networks both atoms (such as airplanes, cars, trucks) and bits (such as telephony and television). Many industrial countries are increasingly nonproductive in the atoms world, unwilling or unable to produce competitive physical goods outside of their own food. Some try to rely on their intellectual property such as the design of physical devices like cars and computers they ultimately buy back in a higher priced physical form. The shift of wealth is likely to continue to be to physical goods producers from information producers because of the near zero cost of goods and disregard for information and intellectual property value. The shift explains why the U.S. had become the world's greatest debtor country by 1996.

The Overflowing Glass

A ubiquitous, high speed, worldwide, single dialtone network that includes homes and our own bodies able to carry fungible bits for voice, video, and all types of data will become the infrastructure. It will enable vast new kinds of communicating components and platforms. Vannevar Bush [2] was prophetic about the

construction of a hypertext-based, library network that he would now recognize as the World-Wide Web. He also envisioned a head-mounted camera to collect and hold personal information. In the very short term, the Web offers the most potential for change at all levels of health care through standardization and universal access, including online information; linking human- and machine-created information, medical equipment, and caring for people by just communicating with them. Eventually this communication could be more tightly coupled using a body-area network linked into ubiquitous, wireless, local area networks.

A region of cyberspace that includes communication with parts of the body has the greatest potential for changing everything from human behavior to health care. Today, wearable computers help workers operate in complex physical and logical spaces such as airplanes and wiring closets. Ultimately, progress can be made to connect prosthetic computers to humans in a biological rather than in the mechanical fashion such as pacemakers. An artificial eye implant could connect to the visual cortex to enhance vision creating a bionic body.

The networked platforms (including communicating body networks) would enable a wide range of apps from personal health care, control, assistance, security, navigation, and communication to enhancement of human functions as a computer-aided reference with total recall! The applications are endless. They more than subsume today's networked computers because of the very different, close man-machine coupling. For example, operating as a guardian angel, the body-networked computers with onboard monitoring would warn of an event such as an impending heart attack. Its utility is provided by a combination of personal information integrated with scientific information coming from new relevant sources such as the *New England Journal of Medicine* or the Centers for Disease Control. It would remind us to wash our hands as a way of dramatically reducing communicable diseases. Sound wild? A bit, but it sure looks possible. ■

REFERENCES

1. Bell, G. and Gray, J. The revolution yet to happen. *Beyond Calculation: The Next 50 Years of Computing*. Copernicus Press, New York, 1997.
2. Bush, V. As we may think. *Atlantic Monthly* (1945). <http://www.isg.sfu.ca/~duchier/misc/vbush/vbush.html>
3. Cochrane, P. Various papers on future computers, including their use for caring for the aged. <http://www.labs.bt.com/people/cochrap/>

GORDON BELL, noted “father” of the minicomputer, is currently Senior Researcher at Microsoft.

Copyright held by the author