Joel Birnbaum

Pervasive Information Systems

the human connection

FOR MANY YEARS, I HAVE DREAMED OF THE DAY WHEN COMPUTERS WOULD become pervasive technology—that is, a technology more noticeable by its absence than its presence—in the same way cars, televisions, and telephones have become part of everyday life for most people. No one is surprised to find a telephone or a TV in a hotel room, but we would be amazed to find a PC; and even if we did find one, most people wouldn't know how to use it.

Electric motors are a good example of a pervasive technology. The average U.S. home contains two dozen or more electric motors. However, because these motors are buried in consumer appliances—like vacuum cleaners, electric toothbrushes, washing machines, and video cassette recorders—we have trouble identifying them and don't know or care how many are in each appliance. In the future, the same will be true for computers, most of which will be hidden in information appliances.

The key inflection point in this evolution was at the beginning of the 1990s when making information technology devices small enough finally led to the ability to specialize them according to their function in sufficient volume they could be priced for mass markets. The architected open interface between service requesters and providers—so-called clients and servers—is the enabling transition for computing technology to become pervasive within the next decade.

Part of the Environment

Alan Kay of Apple Computer once pointed out that only people born before a technology is invented think of it as technology. Everyone else considers it part of the environment. Today's schoolchildren don't think of TVs and telephones as technology—they can't imagine life without them. Tomorrow's children will feel the same way about computers, the networks connecting them, and the services they perform.

History shows us clearly that in the march toward pervasiveness, technologies almost always pass through four stages:

- They begin as laboratory curiosities.
- They are used by a small number of specialists to solve a particular problem.
- They become manufacturable and commonplace but still require a great deal of specialized training and are still used by only a relatively small fraction of the population.
- They become pervasive, viewed as part of the natural world by most people. Achieving this stage is by no means assured, as shown by dirigibles, trolley cars, and many other technologies.

To become truly pervasive, information technology, now nearing the end of the third stage, must transcend being merely manufacturable and commonplace. It must become intuitively accessible to ordinary people and deliver sufficient value to justify the large investment needed in the supporting infrastructure. The invention of Mosaic and other Internet browsers has taken a giant step toward the first requirement, while the World-Wide Web/Internet phenomenon has addressed the second requirement.

Pervasive Computing

A new generation of information appliances will emerge by the end of this century, offering a means to a particular end; their use will seem quite natural to a great many people. They will differ greatly from today's small, mobile, general-purpose computers in what they do and in the much smaller learning overhead they impose on the user. Dedicated to a particular task, they will be named by that task (e.g., washing machine, video cassette recorder), and users will think of them in terms of what they do, not how they do it.

We expect appliances to evolve to hide their own complexity, just as the one-button, automatically tuned TV set today has replaced its less complex but harder-to-adjust ancestor. Because of continued advances in semiconductors and software, the information appliances of tomorrow will do the same. Some interfaces will be invisible; current examples are the computer-augmented steering, braking, and ignition systems in cars. Appliances need not be small or portable; think of furnaces and refrigerators. Regardless of their size, future information appliances will conform to a simple mental model of usage, like the neutral, drive, and reverse of automatic transmissions—a far cry from today's mouse clicks and icons.

Another important change taking place is that, with the emergence of the Internet, we see the first stage of a digital infrastructure that will eventually bring global information and computing to most homes, schools, businesses, and other institutions. Service expectations will change too. Just as people pick up a phone expecting a dial tone, people will expect the information utility to be available, ready, and waiting. For this reason, quality of service will be a crucial competitive differentiator at the systems level and end-to-end systems management will be a major technical challenge.

Client-Utility Computing

In such a high-bandwidth, digital, multimedia world—in which clients (general-purpose computers or appliances) connect to the utility—people could pay for their computing by usage, modulated by guaranteed response requirements. This is an enormous paradigm shift, changing what is now a capital investment into a competitive service, like electricity and water. It will do for computing what the Web did for data.

This scenario is not the ultimate revenge of time sharing, which was proprietary, fixed-resource, and usually location-dependent. In client-utility computing, standards-based open resources, located arbitrarily, are combined as needed for a particular job. It will no longer matter where the computers operate or which manufacturer makes them. Today's suicidal obsolescence schedule will be replaced by the capacity requirements of the service provider, with upgrades undetectable by the end user within a given performance envelope.

I think this is a likely progression, since the end user benefits from greatly decreased cost of ownership, the manufacturers gain a relaxation of insane time-to-market demands, and a new lucrative service industry should emerge. If this new model of computing becomes practical and reliable, history tells us that current manufacturers who do not adjust in time will not be able to satisfy customers and suffer dire consequences.

Much new technology will be needed—mostly middleware to address issues of scale, interoperability, security, robustness, and end-to-end systems management. Developing such technology is not an easy task, but many of the world's computer, telecommunications, and software companies are now busy developing pragmatic engineering solutions to such problems, and I think it is only a matter of time before client-utility becomes the prevalent style in information systems. Major barriers include security good enough to support electronic commerce and technology that measures, manages, and models the complexity of the huge networks.

Consequences

The consequences of pervasive information systems for business and society are enormous. Many industries will change dramatically or be eliminated entirely (if, for example, the print-and-distribute business model is replaced by distribute-and-print, how will publishers, bookstores, and transportation companies respond?). We are entering an era of unprecedented opportunity—perhaps the best of times for technologists and the worst of times for the business people who must place bets on an uncertain future. I can't wait. ◻

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