Ubiquitous Computing : An Interesting New Paradigm

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What is ubiquitous computing ? An exciting new approach to serving us with technology ? A difficult yet rewarding technical challenge ? A concern for privacy advocates ? A good tool in the right hands, and an oppressive one in other hands ? To help us answer these questions, this essay examines the current definition of ubiquitous computing, its development, including the key people and places influencing its development, and finally some concerns raised by this new approach for putting technology and people together.

What is Ubiquitous Computing ?

Ubiquitous computing, or calm technology, is a paradigm shift where technology becomes virtually invisible in our lives. Instead of having a desk-top or lap-top machine, the technology we use will be embedded in our environment. From the ubiquitous computing page at Xerox PARC [UBPARC] we have the following description : imagine a world with hundreds of wireless computing devices of different sizes in the same room. In order to bring this type of computing out into the environment, among the things we need to rethink are user interfaces, displays, operating systems, networks, and wireless communications.

This rethinking demands a radical departure from the tradition of putting machines out for our use, and having us adapt to them. Instead, in the world of ubiquitous computing, technology will be implicit in our lives, built in to the things we use, including the spaces. The proponents of this technology hold that this type of computing will be a more natural tool, and thus a more powerful and effective one for us to use.

Now that it is defined, what are some uses envisioned by its proponents and authors ? In 1991 Mark Weiser, thought of as the founder of what we now term ubiquitous computing, wrote an article for Scientific American entitled "The Computer for the 21st Century". In it, Weiser describes the multiple computers in a room as tabs, pads and boards, which roughly correspond to active Post-It notes, sheets of paper, and white boards and bulletin boards. A good description of these items can be found in the article "Some Computer Science Issues in Ubiquitous Computing". These computers serve many functions as people come in and out of the rooms. The people themselves could be tracked by active badges (based on infrared sensors) or other devices, and email could be forwarded automatically to wherever the person is. Locating people at work to deliver important messages, or for other reasons, is made easy (the possible misuses of these capabilities are probably entering the reader's mind at this point. This concern will be discussed in the Issues and Concerns section below).

Other scenarios given in the article include the coffee starting at your request when the alarm wakes you, seeing "electronic trails" left by people passing through the neighborhood, and automatically transmitting a quote from a newspaper to the office with the swipe of a pen over the newspaper.

With these definitions and examples, we have an idea of what ubiquitous computing is, and what it hopes to achieve. To see how it has evolved, we'll now look at its history.

Development : Short, Active, and Ongoing

Already, one name has been reoccurring when talking about ubiquitous computing : Mark Weiser. The place which has pioneered research on this topic, and where Mark is located is the Computer Science Lab at Xerox PARC. Today's field got started at PARC in 1988, where Mark articulated the approach and the reasoning behind it. As he describes in [UBPARC], interface and computer design had historically been aiming to make computers more "dramatic", that is so exciting and interesting to use that we would not want to do without them. He reasoned that a better approach would be to make the machine disappear, or become hidden from the user, so that its use would be non-intrusive, becoming a graceful part of our everyday life.

In the brief description above, we saw that a re-thinking of almost every aspect of computing needs to be done to realize this vision. For example, power requirements need to decreased. This can be done by reducing the clocking frequency of chips by increasing parallelism or pipelining. Wireless networking needs to be developed to accommodate remote computers "hiding" in our environment. At present, the capability of handling many high speed devices for one person is not available. Besides wireless technology, networking issues such as real-time capabilities for multimedia over standard networks and packet routing need to be addressed. For the white boards, new types of pens working over a large area and with back projection were needed. One approach was to develop infrared pens which rely on a camera-like device behind the screen to sense the pen position [Elrod92].

One can see from just a few of these computer science issues that making ubiquitous computing a reality is an interesting technical challenge. Much of the history since 1988 has involved addressing the technological problems. In addition, conferences have sprung up, and other groups have developed and begun work on issues related to ubiquitous computing. One such group is the Future Computing Environments group at the Georgia Institute of Technology's College of Computing. This group is exploring interesting uses of technology including teaching applications, such as Classroom 2000, and unconventional at-home use in projects such as Domisilica, formerly known as the CyberFridge project (FCE Projects). An interesting application of active badges and music to be presented at the next CHI conference called Audio Aura can be found at here.

Active badges are the work of Olivetti's research center in Cambridge, England. Besides this group, a major interest in computers we can wear has grown out of the ubiquitous computing philosophy, gathering its own momentum and its own particular goals. In the explanation of what a wearable is, the MIT Wearables Group states :

"A person's computer should be worn, much as eyeglasses or clothing are worn, and interact with the user based on the context of the situation. With heads-up displays, unobtrusive input devices, personal wireless local area networks, and a host of other context sensing and communication tools, the wearable computer can act as an intelligent assistant, whether it be through a Remembrance Agent, augmented reality, or intellectual collectives."

Wearable computing seems perhaps less intrusive than the "invisible" computers of ubiquitous computing, for we decide to wear them or not. With ubiquitous computing, we can be tracked, among other things, albeit for helpful purposes. However, the same capabilities can be used for less honorable purposes, which raises one major concern about ubiquitous computing which we will consider in the next section : invasion of privacy.

Privacy and Related Issues

In his Scientific American article, Weiser says that having so many computers in one place may at first seem intimidating, but "like the wires in the walls, these hundreds of computers will come to be invisible to common awareness" [SciAm9_91]. Is it good that the computers are invisible ? Who can turn them off ? Who controls the flow of information, and who has access to it ?

In an article in the October 1994 issue of *The Last Link*, a computer-mediated communication magazine which reports about topics concerning human communication via computers, Stephen Doheny-Farina writes on "Default = Offline Or Why Ubicomp Scares Me". In this article he voices concerns that touch on several issues. Referring to the Orwellian nature of being monitored by active badges or other means, he suggests that Weiser's response -- supporting our right to dissent and not wear a badge -- is backwards. We should not have to dissent to ensure our right to privacy. The default condition should be offline, thus not tracked. He voices concern that PARC is an organization that encourages freedom and privacy among its employees. In other organizations less tolerant of dissent, he wonders what would happen.

Others have wondered the same thing, and the unintended (at least by some) applications of ubiquitous computing technology has people worried. In a broader sense, privacy and computing has been an ongoing issues, well before the arrival of the ubiquitous computing philosophy. What ubiquitous computing contributes to the debate, however, is the condoned tracking of people's movements wrapped in the benevolent guise of helping them. And many people would not use the technology for other purposes. However, is it responsible to ignore or minimize the potential for misuse of a technology simply to realize its benefits ? Perhaps the answer is to ensure checks are in place, legislative and technical, to minimize abuse and maximize use of a new technology. As Doheny-Farina says, "everyone must assume that only extraordinary conditions merit surveillance. The requisite argument must not be, 'why do you not want to wear the badge ?'. The requisite argument must be 'why do you want me to wear it ?'. We must demand that the burden of proof is on the watcher, not the watched".

References

Scientific American, September 1991 [SciAm9_91].

Mark Weiser's papers and list of research papers.

Wired 2.02 article, by Howard Rheingold.

[Elrod92] Elrod, Bruce, Gold, Goldberg, Halasz, Janssen, Lee, McCall, Pedersen, Pier, Tang, and Welch. Liveboard : a large interactive display supporting group meetings, presentations and remote collaboration. pp. 599-607. CHI '92 Conference proceedings. May 1992. ACM, New York, NY.

Olivetti's Active badges.

Ubiquitous Computing Movies.

For further reading

Marx, Gary. "Privacy and Technology". *The World and I*, September 1990.

Rheingold, Howard. *Virtual Communities: Homesteading on the Electronic Frontiers*. Reading, MA : Addison-

Wesley Publishing Company, 1993.

Conferences

Nomadic '96.

Vanguard Conference : January 13 - 15, 1997.

Workshop on Wearable Computer Systems : August 19-21, 1996, Renton, WA.

First International Symposium on Wearable Computers : Oct 13-14, 1997.

CHI'97 Workshop on Research Issues in Wearable Computers : March 23-24.