Hot Topics in Ubiquitous Computing

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A few thousand years ago people of the Fertile Crescent invented the technology of capturing words on flat surfaces using abstract symbols : literacy. The technology of literacy when first invented, and for thousands of years afterwards, was expensive, tightly controlled, precious. Today it effortlessly, unobtrusively, surrounds us. Look around now : how many objects and surfaces do you see with words on them ? Computers in the workplace can be as effortless, and ubiquitous, as that. Long-term the PC and workstation will wither because computing access will be everywhere : in the walls, on wrists, and in "scrap computers" (like scrap paper) lying about to be grabbed as needed. This is called "ubiquitous computing", or "ubicomp".

I first created the idea of ubiquitous computing from contemplation of the place of today's computer in actual activities of everyday life. In particular, anthropological studies of work life [Suchman 1985, Lave 1991] teach us that people primarily work in a world of shared situations and unexamined technological skills. However the computer today is isolated and isolating from the overall situation, and fails to get out of the way of the work. In other words, rather than being a tool through which we work, and so which disappears from our awareness, the computer too often remains the focus of attention. And this is true throughout the domain of personal computing as currently implemented and discussed for the future, whether one thinks of PC's, palmtops, or dynabooks. The characterization of the future computer as the "intimate computer" [Kay 1991], or "rather like a human assistant" [Tesler 1991] makes this inappropriate attention to the machine itself particularly apparent.

Ubiquitous computing has as its goal the enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user. A number of researchers around the world are now working in the ubiquitous computing framework. Their work impacts all areas of computer science, including hardware components (e.g. chips), network protocols, interaction substrates (e.g. software for screens and pens), applications, privacy, and computational methods.

Ubiquitous computing is not virtual reality, it is not a Personal Digital Assistant (PDA) such as Apple's Newton, it is not a personal or intimate computer with agents doing your bidding. Unlike virtual reality, ubiquitous computing endeavers to integrate information displays into the everyday physical world. It considers the nuances of the real world to be wonderful, and aims only to augment them. Unlike PDA's, ubiquitious computing envisions a world of fully connected devices, with cheap wireless networks everywhere; unlike PDA's, it postulates that you need not carry anything with you, since information will be accessable everywhere. Unlike the intimate agent computer that responds to one's voice and is a personal friend and assistant, ubiquitous computing envisions computation primarily in the background where it may not even be noticed. Whereas the intimate computer does your bidding, the ubiquitous computer leaves you feeling as though you did it yourself.

Work on ubiquitous computing is still at an early phase. Most work now is concentrating on the mobile infrastructure for wireless networking. Because ubiquitous computing envisions hundreds of wireless computers in every office, its need for wireless bandwidth is prodigious. For instance, I work in a not-very-large building with 300 other people. If each of us has 100 wireless devices in our offices, each demanding 256 kbits/sec, we are using 7.5 gigabits of aggregate bandwidth in a single building. This is difficult to achieve with currently envisioned wireless technologies.

A second challenge of the mobile infrastructure is handling mobility. Networking developed over the past twenty years with the assumption that a machine's name, and its network address, were unvarying. However, once a computer can move from network to network this assumption is false. Existing protocols such as TCP/IP and OSI are unprepared for to handle machine mobility without change. A number of committees and researchers are now working on methods of augmenting or replacing existing protocols to handle mobility.

A third challenge of the mobile infrastructure is window systems. Most window systems, such as those for the Macintosh and for DOS, are not able to open remote windows over a network. Even window systems designed for networking, such as X, have built into them assumptions about the mobility of people. The X window system protocol, for instance, makes it very difficult to migrate the window of a running application from one screen to another, although this is just what a person traveling from their office to a meeting might want.

For further reading in ubiquitous computing, a paper in Scientific American covers the broad themes [Weiser 91]. For more detailed work, the July 1993 issue of the Communications of the ACM is entitled "Computer Augmented Environments: Back to the Real World" [ACM 93]. This issue is a compendium of papers on the subject of embedding computation in everyday life. Papers in the August 1993 Usenix Conference on Mobile Computing address a number of ubiquitous computing topics [USENIX 93]. The IEEE is launching a new journal of potential relevance to this new field : Personal Computing, edited by Hamid Ahmadi, to start publication in 1994. ARPA recently published a broad agency announcement on Wireless, Adaptive and Mobile Information Systems (WAMIS).

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