DISAPPEARING HARDWARE – UBIQUITOUS COMPUTING

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Abstract: Ubiquitous computing is the method of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user. Mark Weiser, the inventor of Ubicomp, believes that the most profound technologies are those that disappear, and Ubicomp aims towards making computing “invisible”. This paper explains what is new and different about the computer science in new era of ubiquitous computing.

Keywords: ubiquitous computing, wearable computing, tab, pad, PDA, personal system, infrastructure system, proactive interaction, robotics

1. Introduction

The mainframe era represents an era when users had little choice and their actions were driven by the limitations of the system. The computer was a scarce resource, and had to be negotiated and shared with others. The PC era represents more choice, power, and freedom to the users when compared to the mainframes. The PCs are not as costly as the mainframes and are affordable by common people and hence are more widespread. However, when doing personal computing, people are still occupied and are doing little else. Ubiquitous computing represents the next wave of computing, and is mainly characterized by the connection of things in the world with computation. The profounders of this era predict that this era will have lots of computers sharing each of us, embedded in walls, chairs, clothing, light switches, cars in other words, in everything.

Where does the Internet fit in? Though Internet is an important development deeply influencing the business and practice of technology, it is not considered to represent a new "era" of computing. As the Internet brings together the elements of the mainframe era and the PC era, with web clients the PCs and the web servers the mainframes, it is seen as transitional before we move on to the Ubicomp era. It will bring the information technology beyond the big problems like corporate finance and school homework, to the little annoyances like: Where are the car-keys, Can I get a parking place, and Is that shirt I saw last week at Macy's still on the rack? What qualifies this as a fundamental trend? First, it is about basic human relationships with each other and with computers. Second, it has the property of building upon the past (the mainframe and the PCs), and, thirdly, there is scope for innovation requiring reopening old assumptions.

Technology can't truly be helpful unless it can provide the information that you need where you want it, when you want it, and without you needing to manage it. One of the related fields of research, Wearable Computing, aims at making the engineered artefacts surrounding us more intelligent. Clothes and jewellery that we wearing, also, carpets that we walking on, are all blind, deaf, and dumb. Fabrics look pretty, but they should have a brain, too. Glasses help sight, but they don't see. We must expect more from our environment. Hardware and software should merge into "underware".

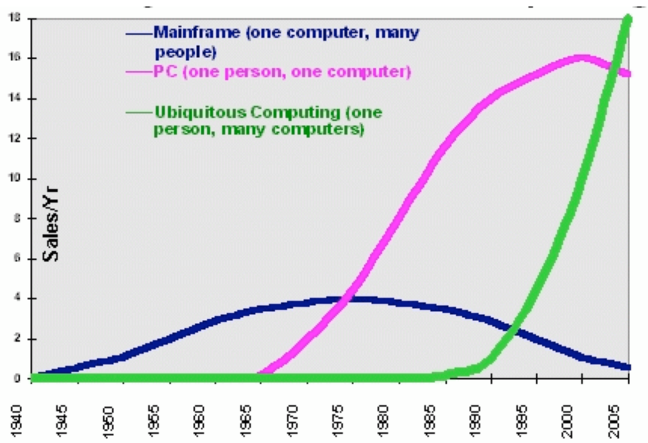


Figure 1: Mayor trends in computing

Consider this, Mark Weiser (1952-1999) wanted to explore whether we could design radically new kinds of computer systems. These systems would allow the orchestration of devices with non-traditional form factors that lend themselves to more natural, tacit interaction. They would take into account the space where people have worked, allowing positional and manipulative, rather than keyboard and mouse, interactions. Along with specialization and use of embedded computers, support for mobile computing and wireless data networks in important facet of this vision, in other words, invisible connectivity.

A goal of this exploration is that we would learn to build computer systems that do not distract the user; ideally the user might be even forgotten the hardware is present. In essence, Weiser proposing that well designed computer systems would become invisible to the user and that our conscious notion of computer hardware would begin to disappear.

2. Short history of events

In late 1987, Bob Sprague, Richard Bruce, and other members of the Xerox Palo Alto Research Center (PARC) Electronics and Imaging Laboratory (EIL) proposed fabricating large, wall-sized, flat-panel computer displays from large-area amorphous silicon sheets. It was thought at the time that this technology might also permit these displays to function as input devices for electronic pens and also for the scanning of images (by placing documents directly against the displays). Quickly, members of other labs were willingly drawn into designing both the hardware and software for this new kind of computer system-one that seemed to honour the transparent ease of use of a traditional whiteboard while extending its power computationally, particularly when networked with other such devices. The research vision these "computer walls" inspired was far different from the then-current "one person-one desktop computer" paradigm and opened up to researchers at PARC the idea of spreading computers ubiquitously, but invisibly, throughout the environment.

At the same time, the anthropologists of the Work Practices and Technology area within PARC, were observing the way people *really* used technology, not just the way they claimed to use technology. To some of the technologists at PARC, their observations led toward thinking less about particular features of a computer and much more about the detailed situational use of the technology. In particular, how were computers embedded within the complex social framework of daily activity, and how did they interplay with the rest of our densely woven physical environment (also known as "the real world")?

From these converging forces emerged the Ubiquitous Computing program in the Computer Science Laboratory (CSL) in early 1988. The program had been at first envisioned only as a radical answer to what was wrong with the personal computer: too complex and hard to use; too demanding of attention; too isolating from other people and activities; and too dominating as it colonized our desktops and our lives. Researchers wanted to put computing back in its place, to reposition it into the environmental background, to concentrate on *human-to-human* interfaces and less on *human-to-computer* ones. By 1992, when first experimental "ubi-comp" system was being implementing, they came to realize that they were, in fact, actually redefining the entire relationship of humans, work, and technology for the post-PC era. Starting in late

1988, there emerged three intertwined major building efforts at PARC within the Ubiquitous Computing program. The large wall-display program, now known as the LiveBoard, continued to be spearheaded from EIL, but migrated from amorphous silicon to rear screen projection. CSL initiated two programs to create smaller computers: the book-sized ParcPad (MPad) and the palm-sized ParcTab. Augmenting these devices was the Active Badge system. These programs: the board, the pad, the tab, and the badge, together with a flexible, computational infrastructure that recognized not just device name, but the location, situation, usage, connectivity, and ownership of each device, staked out a new conception of what computers could be and feel like. By 1994 these ubicomp building programs had produced a working infrastructure for everyday use at PARC.

The LiveBoard, had been commercialized by Xerox in a subsidiary called LiveWorks. Besides the hardware, the LiveBoard came with a collaborative drawing system, spearheaded by Tom Moran, who pioneered shoulder-to-shoulder computing, remote drawing collaboration, casual interfaces, and first-class annotation systems. LiveWorks sold hundreds of units (including units sold to high schools who found that the LiveBoards augmented, rather than replaced, the teachers) before being closed down in 1998. While the LiveBoard more traditionally plugged into the network, the ParcPad maintained constant network connectivity by using a unique "near-field radio" system. The pad itself was based on hardware, a window-and-pen interface system, an operating system, as well as other components created by a wide range of PARC researchers. The pad proved an important platform for radio, protocol, mobile networking, user interface, and work-studies research. The pad's operating system and hardware design have proved their robustness and are still in use in new projects at PARC today.

The ParcTab, was unique in its ability to be used with one hand and its integration using a location-sensitive, agent-based, enterprise-wide infrared network with applications on workstations, LiveBoards, and with other devices, including the now famous coffee- maker. The tab came with a complete suite of real-time networked utilities including e-mail, memo, calendar, sketch pad, address book, pager, and remote drawing tool (which drew on LiveBoards). The tab's alphanumeric input was via a patented Unistroke system, while selections were activated by the touch screen and three ergonomically placed buttons. The tab's simple design philosophy was later extended into other CSL projects to create, among other things, a keychain computer.

The Ubiquitous Computing project at PARC resulted in many fundamental patents and papers, in a wide range of what had been at the time considered independent areas of computer science, including physical transport, network protocols, operating systems, window systems, file systems, user interfaces, energy management, and input design. In the end, ubi-comp created a new field of computer science, one that speculated on a physical world richly and invisibly interwoven with sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of our lives and connected through a continuous network. What is truly startling is how quickly we are finding this new form of computation manifesting itself around us.

3. Basic characteristics

Where we've been? Where we are now? Where we're head? These questions can help us to understand the direction of research and development in the era of ubiquitous computing.

Before couple of years, Mark Weiser's vision was inspiration for research work at: XEROX Palo Research Center (PARC), (Projects were: ParcTab, Mpad, LiveBoard, Olivetti's Research Active Badge, Berkeley's InfoPad), Carnegie Mellon University, Georgia Tech, University of Washington, etc. At that time, Wireless Local Area Network standards not existed, processors suitable for mobile devices operated at only a few megahertz, PCs typically shipped with up to 50 MHz processors, pen-based PDAs (Personal Digital Assistants) hadn't been invented, Electronic organizers proudly claimed 128 Kbytes of memory, PCs shipped with 30 Mbyte Hdisks, displays were quite crude (laptops used monochrome VGA, available handheld devices used character-based displays…**).** But, industry responded to the challenge, as a result mobile computing appeared. One step forward was attempt for making using PC to be equal as using a pen&paper. The results were new devices, better than traditional "pencil and paper technology". On the other hand, physical hardware dominating-design aspect affected acceptance in following areas: size, weight, power consumption, computation, speed, richness of interface, simplicity of design. So, computer industry was beginning to move in right direction!

Today, there are most notable improvements in hardware technology. It's enough to mention new inventions in the following areas of technology: wireless networking, processing capability, storage capacity, high-quality displays, etc. Wireless networking provides two basic needs: ability to detect location and ability to communicate with possibility for portable ubiquitous hardware (connected to global infrastructure). Such examples are: GPS, Bluetooth, IrDA standards. In the field of microelectronics and processing capability, the capabilities of devices increases, smaller transistor dimension implicates higher speeds and increased effective performance. Future tasks are better matching algorithmic complexity and execution speed to real world problems, and reasonable operating time (before batteries fall). Adoption trends towards in following direction: devices such as cell phones, PDAs, and digital cameras are beginning to merge, combined capabilities reducing the number of devices a user must carry. For example, automobile is a particularly outstanding area of success of ubicomp. Modern cars have computer systems integrating control of the engine transmission, climate, navigation, entertainment and communicating systems.

So, where we've head? Current ubiquitous computing research projects fall into these categories:

- Personal systems (mobile and wearable systems)
- Infrastructure systems (associated with a particular physical locale)
- Proactive interaction (interaction of computers with the physical world without direct human involving)
- Robotics (mobilizing a computer and enables it to effect change at arbitrary locations in the real world)

Personal systems give users access to computing independent of their physical location. They could usually be discrete portable devices – which are the most useful personal systems (cell phones and PDAs). They are limited by their computational ability, integration with other devices and interface capabilities, but the fundamental limits are interface capabilities. Wearable computers rely on hardware such as heads-up displays and one handed keyboards to provide the interface to the computer. It is attractive model because of providing fully functional computing experience wherever the user might be. At the other hand, personal servers enhance ubiquitous access to data and form the computation end storage center of a person's digital experience. Devices communicate directly representing an interface into central repository.

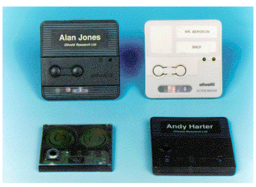
When we talk about infrastructure systems, we can just imagine thousands of miniature temperature sensors deployed around the room. Our first questions will be: How did they get there? How is data collected? How are faulty components identified and replaced? So, the reason for this kind of research will be exploring this space of problems by creating wireless sensor platform and exploring network protocols. In sense of proactive interaction, personal and interactive based systems require some kind of user interface to let humans interact with them, new display technologies that enable rich visual output will be most exiting advance in ubiquitous interfaces, and directly interacting computing with the real world without human interaction will greatly increase computers' impact on our lives. But, today some systems still require human intervention. The challenge is to make these systems proactive. A proactive system must closely and reliably integrate sensors with the physical world. It will require greater sophistication in the components deployed in the environment, both to enable the capability to affect the physical world and to quickly process real-world data. Research in sphere of robotics could be represented with an interesting confluence between mobile and proactive systems: allowing the CS to affect the real world without a priori instrumentation of the environment. But there are difficulties like determining where they are and identifying objects in the environment. That's why we can say that robots are type of disappearing hardware; they allow computation to directly affect the real world. In-door positioning systems would better allow to a robot functioning.

4. Examples of Ubiquitous Computing

4.1 Tabs, Pads, and Boards

The Tab is a tiny information doorway. For user interaction it has a pressure sensitive screen on top of the display, three buttons underneath the natural finger positions, and the ability to sense its position within a building. The display and touchpad it uses are standard commercial units. The Pad is a prototype pen computer. It can communicate through infrared, near field radio, and through a 1Mbps tether. Yard-size displays (boards) serve a number of purposes: in the home, video screens and bulletin boards; in the office, bulletin boards, whiteboards or flip charts.

4.2 Active Badges



The Active Badge system provides a means of locating individuals within a building by determining the location of their Active Badge.

4.3 Living Room - Interactive Wall paper

As technologies merge and miniaturise, we will have flatter displays and sound systems, possibly becoming a 'living wallpaper' of sound and vision. This would create a living room with less clutter, where there are no 'black boxes', but only the sound and vision we wish to experience. These large, flat displays will be able to show multiple images at any size and in any position. Sound and light would also be intelligently controlled to optimise the ambience in the room.

4.4 Intelligent Garbage Can

The Intelligent Garbage Can will optimise waste disposal by sorting, compacting and removing odour ready for collection. As the problems of waste increase and landfills become less attractive as a solution for waste management, more pressure will be placed on individuals to sort their waste into its constituent parts so that these may be recycled more easily and more efficiently. The Intelligent Garbage Can will aid this process by making sorting more convenient.

4.5 Expert Chef

Expert Chef is an interactive tool which enables the user to learn various cooking skills and experiment with cuisines from around the world. Master chefs show us how it is done. We can look up recipes and find information about the history of dishes and the culture they derive from. Searches can be made for recipes which are appropriate to the amount of time available, the skills of the cook and the ingredients to hand. If so desired, the Expert Chef will take the user through all the stages of buying and preparing the ingredients, and then cooking and serving the meal. The information and guidance can be given in real time, as we cook. Expert Chef is an interactive on-line service for the kitchen that guides users in the preparation of dishes from around the globe. Different chefs can be chosen to present the recipes with a style, pace and level of detail to suit individual users.

4.6 Remote Eyes

Remote eyes are small video cameras for the home. Once charged they are nomadic, the only limitation being the signal-transmission range. These cameras are ideal for security applications, remote monitoring of young children in the playroom, or checking the progress of a meal in the kitchen while in the garden. The applications are numerous. For children, it is a fun and engaging toy to play with.

4.7 Interactive Books

Interactive Books combine the traditional intimate and personal qualities of books with interactive touch-screen technology. Text, moving images and sound can be downloaded to provide a never-ending variety of stories. The books will grow up with their readers, taking them from the simple telling of stories with pictures, through learning to read, to embarking on learning another language. The stories combine text, voice, animations and still images. The interactive story book makes its content more stimulating through touch, sound and moving pictures. The stories become more personal through the reader's own input, choosing voices and faces for characters, making one's own pictures, or affecting the outcome.

5. Problems and limitations

Size, weight, energy, user interface are the main problems and limitation ubiquitous computing researches conflicting with. When we talk about size and weight problem, there are **two** fundamental problems: batteries and user interface, because of reaching the point of can't get much smaller and still usable. Energy is necessary resource for vitality of all Computer systems. Solution for embedded systems included in ubiquitous computing is reducing power consumption which results with energy-aware software. Scientists must find alternative and improved energy sources (in field of solar radiation, mechanical vibration, gravitation fields). When this is combined with robotics, we will get a capability for mobile computing that can recharge itself! Problems for user interface are rendering (fundamentally difficult because of size, weight and usability of the systems), reducing size and weight (which means and less visible and sometimes, decreasing usability), etc.

6. Conclusion

Like all great research, the Ubiquitous Computing projects gave us more questions than answers. A new challenge for ubiquitous systems arises because adaptation must often take place without human intervention, to achieve what Weiser called CALM computing. Once the infrastructure was up and running we clearly saw the vast potential of such a system for augmenting and improving work practices and knowledge sharing, by essentially getting the computers out of the way while amplifying human-to-human communication. But simultaneously we came across an unexpected problem, often blared in newspaper headlines as: "Big Brother Comes to the Office." The problem, while often couched in terms of privacy, is really one of control. If the computational system is invisible as well as extensive, it becomes hard to know what is controlling what, what is connected to what, where information is flowing, how it is being used, what is broken (vs. what is working correctly, but not helpfully), and what are the consequences of any given action (including simply walking into a room). Maintaining simplicity and control simultaneously is still one of the major open questions facing ubiquitous computing research.

In the last several years a few of us at PARC have begun to speak of *calm computing* as the goal, describing the desired state of mind of the user, as opposed to the hardware configuration of the computer. Just as a good, well-balanced hammer "disappears" in the hands of a carpenter and allows him or her to concentrate on the big picture; we hope that computers can participate in a similar magic disappearing act. But it is not so simple. Besides the daunting computational and infrastructural problems, we must also find the balance between control and simplicity, between unlimited power and understandable straightforwardness, between the seduction of smooth digital mediation and the immediacy of those complex fellow workers called humans. But in the end, it is hard to imagine a more important task for twenty-first century technologists then deploying ubiquitous computing projects.

7. References

1. http://www.ubiq.com/hypertext/weiser/UbiHome.html
2. http://www.parc.xerox.com
3. http://www.cc.gatech.edu