Chapter 1.1
Introduction to Ubiquitous Computing

Max Mühlhäuser
Technische Universität Darmstadt, Germany

Iryna Gurevych
Technische Universität Darmstadt, Germany

A BRIEF HISTORY OF UBIQUITOUS COMPUTING

Mark Weiser

The term ubiquitous computing was coined and introduced by the late Mark Weiser (1952-1999). He worked at the Xerox Palo Alto Research Center (PARC, now an independent organization). PARC was more or less the birthplace of many developments that marked the PC era, such as the mouse, windows-based user interfaces, and the desktop metaphor (note that Xerox STAR preceded the Apple Lisa, which again preceded Microsoft Windows), laser printers, many concepts of computer supported cooperative work (CSCW) and media spaces, and much more. This success is contributed (among other reasons) to the fact that PARC managed to integrate technology research and humanities research (computer science and "human factors" in particular) in a truly interdisciplinary way. This is important to bear in mind since a considerable number of publications argue that the difference between UC and Ambient Intelligence was the more technology/networks-centered focus of the former and the more interdisciplinary nature of the latter that considered human and societal factors. We do not agree with this argument, in particular due to the nature of the original UC research at PARC—and the fact that quite a number of UC research labs worldwide try to follow the PARC mindset. Indeed, Mark Weiser concentrated so much on user aspects that quite a number of his first prototypes were mere mockups: during corresponding user studies, users had to imagine the technology side of the devices investigated and focus on use cases, ideal form factors and desired features, integration into a pretend intelligent environment, and so forth.

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Weiser's Vision of UC

Mark Weiser's ideas were first exposed to a large worldwide audience by way of his famous article *The Computer of the 21st Century,* published in *Scientific American* in 1991. A preprint version of this article is publicly available at: http://www.ubiq.com/hypertext/weiser/SciAmDraft3.html.

Maybe the most frequently cited quotation from this article reads as follows: "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." This was Mark's vision for the final step in a development away from "standard PCs", towards a proliferation and diversification of interconnected computer-based devices. A deeper understanding of Mark Weiser's visions can be drawn from his position towards three dominant, maybe overhyped trends in computer science at his time: virtual reality, artificial intelligence, and user agents. With a good sense for how to raise public attention, Mark criticized these three trends as leading in the wrong direction and positioned UC as a kind of "opposite trend". We will follow Mark's arguments for a short while and take a less dramatic view afterwards.

UC vs. Virtual Reality (VR)

According to Mark, VR "brings the world into the computer", whereas UC "brings the computer into the world". What he meant was that VR technology is generally based on elaborate models of an existing or imagined (excerpt of the) world. This model contains not only 3D (geometric) aspects but many more static and dynamic descriptions of what is modeled. For instance, digital mockups of cars have been pushed to the point of simulating crash tests based on the car /obstacle geometry, static, and dynamic material characteristics, laws of physics, and so forth. As the sophistication of models grows, more and more aspects of the world are entered into the computer, finally almost everything happens in the virtual space and even the human becomes a peripheral device for the computer, attached via data gloves and head-mounted displays. Mark Weiser criticized mainly the central and peripheral roles of computers and humans, respectively. He proposed to follow the UC vision in order to *invert* these roles: by abandoning the central role of computers and by embedding them in the environment (in physical objects, in particular), room is made for the *human in the center.* In this context, he used the term "embodied virtuality" as a synonym for UC. The cartoons in Figure 1 were made by Mark Weiser and provided by courtesy of PARC, the Palo Alto Research Center, Inc.

UC vs. Artificial Intelligence (AI)

In essence, Mark Weiser criticized the overly high expectations associated with AI in the 1980's. In the late 1980's and early 1990's, that is, at the time when he developed his UC vision, AI research had to undergo a serious confidence crisis. The term AI had not been associated with a commonly accepted, reasonably realistic definition, so that the association with human intelligence (or the human brain) was destined to lead to disappointments. The AI hype had provided researchers with considerable funds—but only for a while. Mark Weiser proposed to take a different approach towards a higher level of sophistication of computer-based solutions (which had been the goal of AI at large). He considered it a more reasonable objective to concentrate on small subsets of "intelligent behavior" and to dedicate each computer to such a subset. Higher sophistication would be fostered by interconnecting the special-purpose computers and by making them cooperate. This reasoning lead to the term *smart,* considered more modest than the term *intelligent.* Sensor technology plays an important role in dedicating computers to a small subset of "understanding the world around us" (a key element of intelligent behavior). By widely deploying and interconnect-

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