A Catalyst for Mobile and Ubiquitous Computing

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cat·a·lyst

a person or thing acting as the stimulus in bringing about or hastening a result

Webster's New World Dictionary, 1986

The convergence of wireless communication and portable computers is happening before us today. Hardly a week passes without an announcement by some major player in this arena about technology, deployment, or a new strategic partnership. Well-attended conferences and workshops attest to the vibrancy of the research community in this area. Something big is clearly under way. Where will it take us?

Mark Weiser described a tantalizing destination just over a decade ago. In a seminal article, "The Computer for the 21st Century," he described a hypothetical world in which humans and computers were seamlessly united. The article's opening words are memorable:

The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.

He called this vision *ubiquitous computing*. Its essence was the creation of environments saturated with computing and communication yet gracefully integrated with human users.

When articulated, this was a vision far ahead of its time—the hardware technology needed to achieve it simply did not exist. Not surprisingly, the implementation attempted by Weiser and his colleagues at Xerox Parc fell short. After a decade of hardware progress, many critical elements that were exotic in 1991 are now viable commercial products: handheld and wearable computers, wireless LANs, and devices to sense and control appliances. We are now better positioned to begin the quest for Weiser's vision.

MISSION

IEEE Pervasive Computing's mission is to be a catalyst for progress toward this vision. As a magazine rather than a transactions, it is well suited to this role. Because mobility brings unique chal-

lenges of its own, we identify it explicitly in this magazine's charter.

One of the most difficult challenges in realizing Weiser's vision is that it requires a multidisciplinary approach. A successful deployment will require the collaboration of hardware designers, wireless engineers, human-computer interaction specialists, software system developers, and so on. This magazine will serve as a forum for timely material to bring these diverse communities together.

Fostering dialog and collaboration across these diverse technical communities will be the touchstone of our editorial decisions. We envision many different types of articles, such as research reports of ongoing projects, survey articles on the state of the art in different areas, and interviews with system architects and lead implementers. Ensuring that articles are readable and useful to a wide segment of the readership while still being of interest to specialists will be a challenge. Please give us your constructive feedback as we strive to balance these considerations.

ORGANIZATION

The range of topics this magazine will cover is far broader than any single person's expertise. Hence, we've grouped the topics into five broad areas, each with an associate editor in chief to assist me in making sound editorial decisions. The areas and AEICs are

- *Hardware technologies*: Roy Want, Intel Research
- *Software infrastructure*: Tim Kindberg, Hewlett-Packard Laboratories
- *Sensing and influencing the physical world*: Deborah Estrin, University of California, Los Angeles
- *Graceful integration with users*: Gregory Abowd, Georgia Institute of Technology
- *Deployment, scalability, security, and privacy*: Nigel Davies, Lancaster University and University of Arizona

These areas overlap significantly, and articles might span multiple areas. Indeed, the frequent appearance of articles in which these areas are blurred will be a symptom of good health. After all, stimulating work that leads to such articles is this magazine's goal.

In addition to full-length articles, each issue of the magazine will have short pieces in four departments. The departments and their editors are

- *Applications*: Vince Stanford, National Institute of Standards and Technology
- *Education and Training*: Scott Midkiff, Virginia Polytechnic Institute and State University
- *Standards, Tools, and Best Practices*: Sumi Helal, University of Florida
- *Wearable Computing*: Thad Starner, Georgia Institute of Technology

As the magazine evolves, we will also experiment with other kinds of content. For example, the magazine might contain reports of relevant conferences and workshops. Other examples include reviews of hardware and software products, opinion pieces, and news items. We anticipate many special issues, each focusing on a particular topic. The next two issues, for example, will cover integrated pervasive computing environments and context-aware computing. The latter issue will be jointly produced with *IEEE Personal Communications*. It will be the first tangible product of a mutually beneficial collaboration that we foresee between these two magazines.

TERMINOLOGY

In the mid 1990s, the term *pervasive computing* came to represent essentially the same vision that Weiser defined. More recently, researchers have proposed other visions, such as *proactive computing* and *autonomic computing*. This proliferation of terms can be quite confusing, especially since they are all speculations about the future.

In many ways, we are like the proverbial blind men touching different parts of an elephant and trying to visualize the whole. Proactive computing, for example, focuses on improving performance and user experience through speculative or anticipatory actions. Autonomic computing focuses on improving user experience through the system's self-regulation. Proactive and autonomic behavior are important aspects of Weiser's vision, but their overlap with ubiquitous computing is only partial; we can envision those behaviors in many systems unrelated to ubiquitous computing.

This magazine will treat *ubiquitous computing* and *pervasive computing* as synonyms—they mean exactly the same thing and will be used interchangeably throughout the magazine. Although Weiser introduced the term ubiquitous computing, there is reason to believe that he was not wholly satisfied with it. Toward the end of his 1991 article is the following passage:

> Sitting back and reading the paragraph, Sal wants to point to a word. She gestures again with the "Joe" tab onto a nearby pad and then uses the stylus to circle the word she wants: "I think it's this term 'ubiquitous.' It's just not in common enough use and makes the whole passage sound a little formal. Can we rephrase the sentence to get rid of it?"

INAUGURAL ISSUE

We dedicate this first issue, "Reaching for Weiser's Vision," to Mark Weiser. We begin with his original 1991 article, reprinted with the permission of *Scientific American*. We then present five invited articles by the AEICs and coauthors, each examining the state of the art in one of the five areas of pervasive computing mentioned earlier. Each article begins by crisply characterizing the relevance of its area to Weiser's vision. It then summarizes recent advances and asking if they suggest any refocusing of Weiser's vision. Finally, the article looks out into the future and identifies the challenges ahead in its area:

- "Beyond Prototypes: Challenges in Deploying Ubiquitous Systems," by Nigel Davies and Hans-W. Gellersen,

describes technical and social advances in ubiquitous computing and presents key reasons why, despite advances, we are still falling significantly short of realizing the type of world Weiser envisioned.

- "Disappearing Hardware," by Roy Want, Trevor Pering, Gaetano Borriello, and Keith Farkas, discusses ubiquitous hardware, reviewing how close we are to Weiser's vision and what will be enabled in the future.
- "The Human Experience," by Gregory Abowd, Elizabeth Mynatt, and Tom Rodden, defines the scope of human experience in pervasive computing and discusses evaluation as well as social implications.
- "Connecting the Physical World with Pervasive Networks," by Deborah Estrin, David Culler, Kris Pister, and Gaurav Sukhatme, discusses issues related to sensing, actuation, localization, and node resource constraints. It reviews developments of the last decade, trends, and challenges.
- "Software Infrastructure for Ubiquitous Computing," by Tim Kindberg and Armando Fox, discusses the defining characteristics of ubiquitous systems—integration with the physical world and ad hoc interoperability—and presents criteria for ubiquitous computing software research.

This issue also includes pieces in the four departments, each providing a thought-provoking report or perspective on an aspect of pervasive computing. Vince Stanford reviews pervasive computing and elder care, and Thad Starner offers an overview of wearable computing. Sumi Helal discusses pervasive Java, and Scott Midkiff discusses a multidisciplinary design course on the rapid prototyping of computing systems.

ACKNOWLEDGMENTS

The birth of a new magazine is not the work of one person. Many people have worked very hard and shown excellent team spirit in making this happen. It is a pleasure to recognize their contributions.

The IEEE Computer Society's 2001 president, Benjamin Wah, and publisher Angela Burgess and assistant publisher Dick Price provided leadership for creating this magazine. Their wise counsel and support has been invaluable to me in the magazine's formative stages. Crystal Chweh, Shani Murray, and their colleagues have done a fine job in transforming raw content into this inaugural issue. As a novice in the role of editor in chief, I am grateful to the Computer Society staff for their patience and good cheer in helping me learn my role.

The founding editorial board of this magazine is almost a "Who's Who" of the pervasive computing field. In spite of their busy schedules and many responsibilities, the board members have contributed high-quality time and attention to the creation of this magazine. They have offered valuable insights and good suggestions on content, structure, and other aspects of the magazine. They have also done a wonderful job of producing detailed reviews of the articles for this issue in a short amount of time.

The AEICs and the department editors have done an amazing job of authoring articles and department pieces of high quality for this inaugural issue under tight time constraints. I couldn't have asked for a better group of colleagues to share custody of magazine content. I look forward to working with them and the others for the rest of my term as editor in chief.

A NEW FRONTIER

When describing his vision, Weiser was fully aware that attaining it would require tremendous creativity and effort by many people, sustained over many years. The early decades of the 21st century will be a period of great excitement as we engage in the research and deployment challenges of pervasive computing. Like the frontier of the American West in the early 19th century, pervasive computing offers new

beginnings for the adventurous and the restless—a rich open space where the rules have yet to be written and the borders yet to be drawn. We hope this magazine can help you reach and inhabit that frontier. ℗

Mahadev Satyanarayanan is the Carnegie Group Professor of Computer Science at Carnegie Mellon University. He is currently on partial sabbatical, serving as the founding director of Intel Research Pittsburgh. He is an experimental computer scientist who has pioneered research in the field of mobile information access. One outcome of this work is the Coda File System, which supports disconnected and bandwidth-adaptive operation. Microsoft has incorporated key ideas from Coda into the IntelliMirror component of Windows. Another outcome is Odyssey, a set of open-source operating system extensions for enabling mobile applications to adapt to variation in critical resources such as bandwidth and energy. Coda and Odyssey are building blocks in Project Aura, a research initiative at Carnegie Mellon to build a distraction-free ubiquitous computing environment. Earlier, he was a principal architect and implementer of the Andrew File System, which was commercialized by IBM. He received his BTech and MTech from the Indian Institute of Technology, Madras, and his PhD in computer science from Carnegie Mellon. He is the founding editor in chief of *IEEE Pervasive Computing*. Contact him at satya@cs.cmu.edu.

COMING NEXT   COMING NEXT

Integrated Pervasive Computing Environments

The April–June issue will offer a survey of pervasive computing projects and case studies in academia and industry.

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