GUEST EDITORIAL

Smart Spaces and Environments

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The seminal article on "Ubiquitous Computing" by the late Mark Weiser predicted a vision for the future where computer networking technology will be used not just for person-to-person or person-to-computer communication, but also for creating smart environments with people interacting and controlling the physical world. Since then, the tremendous progress in cheap, miniature, and low-power embedded processors, wireless communication modules, and sensors/actuators have brought us closer than ever to realizing Weiser's vision.

Indeed, there is currently tremendous research activity in industry and academia on related technologies such as networked Web appliances, sensor networks, Bluetooth service discovery protocols, context-aware applications, and tangible user interfaces. These resulting new systems will allow people to literally communicate with their physical world, as opposed to the people-to-people and people-to-computer communications enabled by current technologies. They inject a sense of the real world into user interaction by allowing them to query, sense, and perhaps even manipulate the state of their surroundings. For example, various research groups are exploring the use of networked embedded wireless sensor nodes for monitoring of biological habitats, disaster areas, planets, classrooms, museums, battlefields, and so on. These nodes self-organize themselves into ad hoc networks, divide the task of monitoring among themselves in an energy-efficient manner, adapt their overall sensing quality to the available resources, and reorganize upon failure or addition of nodes. Sensors tagged to physical equipment can allow automatic tailoring of environmental settings, and condition-based maintenance.

This special issue is organized into two sections. The first section, organized by co-guest editors Badrinath and Srivastava, is a collection of original articles that address research challenges and problems in this new paradigm of a networked physical world. These articles were selected from submissions in response to an open call for papers. The second section, organized by co-guest editors Mills, Scholtz, and Sollins, is based on a workshop on Smart Spaces that was organized in July 1999 by DARPA, NSF, and NIST to explore challenging multidisciplinary research problems in Ubiquitous Computing.

The first section consists of four articles. The first article is about the concept of dataspaces by Tomasz Imielinski and Samir Goel. This article describes mechanisms for mapping queries to lower-level network broadcast primitives. This mapping enables scaling of the cost of querying large-scale sensor networks. The model has a spatial component built in so that queries can be directed at specific physical cubes, and by doing so the information about the surrounding physical space is obtained as a response.

The second article, by Philippe Bonnet, Johannes Geheke, and Praveen Seshadri, is on querying the physical world. This article presents the concept of a device database system wherein query processing is tightly integrated with the network of devices. It addresses challenges in designing a device database system, and presents an architecture for the system.

The third article, by Katayoun Sohrabi, Jay Gao, Vishal Ailawadhi, and Greg Pottie, is on a protocol suite for large-scale and self-organizing networks of energy-constrained wireless sensor nodes. The article describes energy-efficient algorithms for sensor network medium access control, mobility management, routing, and formation of subnetworks for data fusion and cooperating signal processing.

Finally, the article by Nirupma Bulusu, John Heidemann, and Deborah Estrin addresses the problem of localization in a network of very small devices (e.g., wireless sensor nodes). Specific constraints of the environment such as power, no GPS, and costs are taken into consideration in designing a coarse-grained localization algorithm based on an idealized radio model. It also describes a simple implementation of the model and presents experimental results.

Complementing the above articles is the second section of this issue, which contains an introduction to the NSF/DARPA/NIST Smart Spaces Workshop by the three involved co-guest editors, followed by a summary of the workshop by Dr. Gregory Abowd of Georgia Tech and expanded position papers from selected workshop attendees.

Biographies

B. R. Badrinath is currently an associate professor in the Computer Science Department at Rutgers University and the associate director of WINLAB. He is a co-principal investigator of the DataMan project at Rutgers University. His research interests are in the area of mobile computing. As part of his research, he is developing protocols and services suited for mobile and wireless environments. His current project is called Digital Sprinklers, an information architecture to sensor networks.

MANI SRIVASTAVA (mbs@ee.ucla.edu) is an associate professor at the University of California at Los Angeles (UCLA). Previously, he received M.S. and Ph.D. degrees from Berkeley, and worked for several years in networked computing research at Bell Laboratories. His current research at UCLA is on networked and embedded systems, focusing particularly on low-power systems, sensor networks, smart environments, high-performance wireless systems, and design optimization for embedded systems. He leads DARPA and NSF funded projects in these areas. He has several patents, and has published extensively. His recent awards include ACM Design Automation Conference 2000 Student Design Contest Honorable Mention, the Okawa Foundation Grant, and the NSF CAREER Award.