31 UBIQUITOUS COMPUTING IN PRACTICE

Dick Braley
FedEx Services
Memphis, TN U.S.A.

Andy Fano
Accenture Technology Labs
Chicago, IL U.S.A.

Ora Lassila
Nokia Research Center
Boston, MA U.S.A.

John Light
Intel Research
Hillsboro, OR U.S.A.

Matt Germonprez
University of Wisconsin, Eau Claire
Eau Claire, WI U.S.A.
Case Western Reserve University
Cleveland, OH U.S.A.

Ubiquitous computing is intended to support new information environments, up to the minute sensory information, and context recognition. Companies around the world are implementing ubiquitous computing to support these needs in the form of short-range wireless systems for vehicle monitoring, sensor networks for complex systems management, and context aware devices for *ad hoc* networking. Participants of this panel illustrate how some of the world's leading companies are using ubiquitous computing. In addition, the participants raise questions about the impact of ubiquitous computing, intended and unintended, on both social and technical outcomes.

The FedEx Operating Companies provide a natural setting for the implementation and application of ubiquitous information environments because of their many service

systems including a courier work force serving millions of customers worldwide, tens of thousands of trucks and delivery vans, sort facilities around the globe, and stations and customer service locations worldwide. FedEx is interested in how the philosophy and technology related to ubiquitous information environments can impact work environments, productivity enhancements, and customer satisfaction. The use of specific technologies such as Bluetooth, ZigBee, GPRS, CDMA, Software Defined Radios, "Smart Dust," and sensors by FedEx in ubiquitous information environments raises questions of how these specific technologies can help coordinate the aforementioned service systems and enhance the likelihood of success in implementing large-scale business solutions.

At Intel Research, wireless sensor networks are recognized as having the potential of revolutionizing how we see our world. These sensor networks are deployed over very large areas, without the expensive and often destructive installations that accompany centralized systems. They are in their infancy, so large-scale wireless sensor networks today might involve 65 sensor nodes covering an area of two acres. Ultimately, these networks may allow us to keep track of all the oceans, wilderness, farmland, and complex human-built systems to a level that allows them to be managed more efficiently and effectively. In the process of building several such networks, Intel has identified key technological and informational questions that must be resolved to enable more widespread use. One such deployment, in a Canadian vineyard, emphasizes three informational questions of how to determine the density of sensor nodes needed, what data should be collected, and how to make the information available to people so it can be most useful. Scaling these questions to thousands or millions of nodes makes compelling information technology questions.

Accenture Technology Labs developed the Accenture Remote Sensor Network prototype, a wireless mesh network of sensor nodes that can be spread across any area (from a factory to a forest floor), enabling organizations to gain unprecedented visibility and insight into product conditions and operations. To demonstrate how the network functions in a rugged, real-world environment, the Accenture Technology Labs' R&D team launched a field test with a vineyard in Northern California. The test involved embedding a network of wireless sensors across a 30 acre area to continuously sense humidity, wind, water, and soil and air temperature. Challenges the Accenture team overcame during testing included protecting the hardware from the elements and rodents, ensuring the reliability of the communication link, and, most importantly, building the right insight applications needed to make data useful for decision-making.

Nokia uses ubiquitous computing technology to better adapt to user tasks through automatic context recognition. The context can have many dimensions, such as a device's location, time of day, environment (outdoors, indoors, in the car, etc.), ambient noise level, and temperature. Context definitions, however, require complex knowledge representation to realistically model the real world. Mobile phones, in their smart-phone manifestations, are true ubiquitous computing devices, capable of communicating in an *ad hoc* fashion with other devices near and far. This communication, while potentially benefitting from context information, can also serve as a source of information for identifying the device's context. Semantic Web technologies offer a convenient yet powerful framework for supporting context-awareness, and are well suited to enhance interoperability. At Nokia, context recognition raises questions about what sophisticated

approaches are required to support interoperability and *ad hoc* networking in ubiquitous computing environments.

Mark Weiser's vision of ubiquitous computing is becoming increasingly apparent in today's computing landscape. We must understand the technologies we are capable of working with, the processes and systems we expect these technologies to support, and the questions within this computing paradigm in order to engage in dialogue, research, and practice regarding ubiquitous computing. In this panel, panelists present technologies, systems, and questions that exist at some of the foremost companies using ubiquitous computing. We hope this will provide a forum for rich dialogue among practitioners and academics that will inform and shape our theories and practices with increasingly ubiquitous information environments.