Conferences

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Pervasive 2007: It's about the User

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As sensors, communication devices, and mobile computing become embedded in human activities, a wide range of challenges and opportunities emerge. On 13–16 May 2007, academics and industry representatives met at the Fifth International Conference on Pervasive Computing in Toronto. With over 300 attendees from Asia, Australia, Europe, and North America, this was the largest Pervasive Computing conference to date.

Pervasive 2007 focused on interrelated topics: modeling, sensor devices, design, user interaction and experience, evaluation, and software engineering principles for pervasive interactive systems. It also addressed the important issues of privacy and security. In this article, we highlight the major themes touched throughout the conference.

BENEFITING USERS

The conference's main focus was evaluation of user benefits. Pervasive computing is as much about the user as it is about the technology. So, this conference emphasized desirability rather than just feasibility. Christof Roduner and his colleagues (ETH Zurich) illustrated this point with their concept of mobile phones as universal controllers. While the underlying technical question was how to design mobile phones to control household appliances, the more important research questions were whether and how such control can be desirable.

Comparing different technological approaches was also important, because there are many ways to solve the same technical problem. Stavros Garzonis and his colleagues (University of Bath, Vodafone UK) considered the usability and effectiveness of Near Field Communication and 2D bar codes. They found advantages to NFC tags for trained users but found 2D bar codes more effective for untrained users. They concluded that training and comfort with a new technology are important to its success and acceptance.

Pervasive computing touches all aspects of life, including sports. Mitchell Page and his colleagues (University of Sydney) developed an augmented basketball jersey. The jersey displays a basketball game's data and statistics in real time, to affect other players and make the game more interesting. This makes the game more strategic, with players reacting to background information about other players and game results that they can readily see on other players' jerseys.

Christian Metzger and his colleagues (ETH Zurich) demonstrated the benefits of pervasive computing technologies in a retail setting. They developed a low-cost, weight-sensitive foam that monitors the weight of items placed on it. The foam lets stock managers determine whether products need to be restocked on retail shelves and assists in inventory management.

While user benefits of these applications are apparent, several presentations also showed negative results, highlighting the difficulty of predicting user benefit without extensive methods of end-user study. For example, Matthias Sala and his colleagues (ETH Zurich, Palo Alto Research Center) showed that context-sensitive advertising produced inconclusive results, with users having no clear preferences. Six participants used their Proactive Experience Sampling Tool, a mobile phone-based tool, to periodically label the activities in which they were engaged. Their phones then displayed advertisements intended to be both relevant and helpful to the activity. The experiment demonstrated that the relevancy of advertisements can be improved. However, the researchers observed no significant improvement in the helpfulness of the advertisements, which they attributed largely to the limitations of keyword-based advertisements.

The need to predict user benefits is motivating interesting research in another active research area of *human-information interaction*. Two tutorials addressed methods for conducting end-user studies. Ken Anderson (Intel Research) and Paul Dourish (University of California, Irvine), in "Ethnography: Thick and Thin," discussed the history of ethnography and its importance as a qualitative method for evaluating the user and capturing the user's behavior regarding the pervasive technology. On the other hand,

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Gregory Abowd (Georgia Institute of Technology) presented "Evaluation of Real Deployments in Ubicomp," where he discussed techniques for evaluating pervasive systems deployed in the real world, such as surveys, controlled studies, and experience sampling.

INTERACTING WITH THE PHYSICAL WORLD

In the tutorial "Interacting in Ubiquitous Computing Environments," Tom Rodden (University of Nottingham) stressed the need for less intrusive methods of computer interaction to make them more natural and intuitive. This topic recurred throughout the conference presentations, posters, and demos.

David Merrill and his colleagues (MIT Media Laboratory) presented an example of less intrusive computer interaction methods. They used transponders and user-worn sensors to detect the location toward which a user is pointing, looking, or reaching during physical activity and to provide relevant information to facilitate task completion. For instance, while the user is shopping, the sensors help match items on a shopping list with personal dietary constraints, and the user can determine what not to buy at a glance.

A poster by Aras Bilgen and his colleagues (Georgia Institute of Technology, Microsoft Research) depicted how to use infrared communication ports to detect gestures and perform actions such as moving a slide presentation from a phone to a projector.

Yuji Ayatsuka (Sony) presented his fractal code, which adds a layer on top of a typical 2D bar code. This extra layer overcomes 2D limitations on bar code size and reading distance and angles.

GROUP AND SOCIAL INTERACTIONS

Another conference theme involved studying social interactions to learn how to enhance pervasive computing systems.

Raluca Marin-Perianu and her colleagues (University of Twente) presented a technique for detecting groups on the basis of correlated movements, which uses accelerometers and tilt switches to detect synchronized movements. They demonstrated their technique using remote-control cars outfitted with sensors. Jeremiah Scholl and his colleagues (Norwegian Centre for Telemedicine) studied mobile communication in an oncology department to enhance behavior and interaction among doctors and nurses. Their study provides insight into a complex, interactive work environment where there is a strong need to balance availability with the disruptive effect of interruptions.

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Interestingly, some presenters switched the focus from HCI to nonhuman-computer interaction. In one video demonstration, James Young and his colleagues (University of Calgary) employed Sony AIBO robots to move and interact on behalf of a remote user, to enable group interactions in a remote setting. In another video demonstration, Young and his colleagues used computer technology to remotely play with a pet cat. These demonstrations certainly extend the range of pervasive computing applications.

EXTENDING CONTEXT

The research community has come a long way in terms of deriving contextual information from sensors and using this information in meaningful ways. In previous research, context sensors pushed technology without any particular application in mind. Now we see applications that require contextual data gathering, so the tide has turned to applications pushing sensor technology. The ability to track a game and to display game-relevant information on a wearable sports jersey or the ability to monitor users' cell phone activity and deliver context-sensitive advertising, as we discussed previously, demonstrates how context can be used to pull appropriate data and applications to supplement daily activities.

Mark Assad and his colleagues (University of Sydney) presented the PersonisAD framework, which aims to simplify ubiquitous-application development through consistent models of several fundamental elements. Notably, they have used PersonisAD to automatically select music tailored to users on the basis of preferences and geographical area, using either a categorically determined place (for example, at work) or latitude and longitude.

The Best Presentation award went to Rene Mayrhofer and his colleagues (Lancaster University) for their presentation of a novel acceleration-based authentication technique. Their study used "co-movements" of objects to authenticate an action, such as pairing a Bluetooth headset with a mobile phone by shaking them in one hand.

Anind Dey (Carnegie Mellon University) presented a tutorial on building context-aware systems, in which he reviewed past research and showed how the research community has evolved. He argued that a key challenge in building context-aware systems is the design process. Finally, he outlined challenges for researchers in this space, including the usability of the context-aware system, taxonomy and modeling, and developing an environment model for capturing and disseminating real-world knowledge.

FINDING AND POSITIONING

Location plays an important role in pervasive computing applications. However, finding and positioning people and objects indoors is difficult, given the degree of precision needed and potential interference sources. Con-

ference presenters discussed several approaches to indoor positioning, motivated by different challenges.

One challenge is limited power and computational capability. Mikkel Kjaergaard and his colleagues (University of Aarhus, University of Munich) presented a novel location-fingerprinting approach, using received-signal-strength (RSS) patterns to detect location transitions across geographical zone boundaries, instead of the more common method of using RSS to detect arbitrary positions. The experiment demonstrated that this new approach improves power consumption, reduces bandwidth requirements, decreases computational complexity, and increases privacy.

Indoor positioning, especially precise subroom positioning, often requires the installation of beacons or cameras, which can be cost prohibitive. Using computer vision techniques and eliminating the need for beacons, Moritz Koehler and his colleagues (University of Munich, Georgia Institute of Technology) developed the TrackSense prototype. TrackSense tracks a grid pattern projected onto surfaces in a room. Using a camera, it senses distortions in the grid pattern to detect walls and corners, and uses this information to determine location and orientation within a room. The technique reportedly performs well, within a few centimeters or degrees in accuracy.

Similarly, Christian Frank and his colleagues (ETH Zurich, DoCoMo Euro-Laboratories) presented their unconventional Objects Calling Home architecture. By exploiting the basic omnipresent mobile phone network infrastructure, this architecture lets users employ sensor-equipped mobile phones to locate lost objects that have RFID tags or inexpensive Bluetooth discoverable tags.

PERVASIVENESS AND PRIVACY

Personal privacy versus invasiveness remains a significant concern to the research community. The tension between transparency and user control in pervasive applications was evident throughout the conference, beginning with Adam Greenfield's keynote address on "Everyware." Greenfield argued that pervasive devices' behavior must be clear to end users. This raises an important question: how does a user know how much privacy is necessary when using a particular pervasive application?

The underlying issue then is how to design systems that exploit pervasiveness while putting control firmly in the user's hands. The attempt to balance these contrasting requirements is apparent in Apu Kapadia and his colleagues' (University of St Andrews, UK, and Dartmouth College) "virtual walls" research, voted Best Paper, which aims to protect the digital privacy of users in pervasive environments. The virtual walls allow different degrees of privacy among participants at a particular location.

John Krumm's (Microsoft Research) research shows how information from location-tracking applications can be used to infer home addresses, and how his method of obfuscating this information can prevent such inferences. This research raises the broader concern of how data gathered by pervasive applications may be used in unexpected and possibly invasive ways. Such unexpected uses confound users' ability to control how their information is used, because they might be unaware of how the data could be exploited.

Pervasive 2007 provided a view of future possibilities, interactions, and applications for pervasive computing. With the resources available today, researchers are seeking and evaluating prototypes of leading-edge applications. The overarching goal is for interactions with computer artifacts to be seamless, natural, and effortless. Nevertheless, privacy, security, ethical, and social concerns remain critical issues. The challenge is to produce novel tools that serve the users' interests while taking legal and ethical issues into account. Where we as human beings choose to locate ourselves within the spectrum of complete automation versus purely human-initiated mediation will be key to pervasive computing's success.

You can find photos from Pervasive 2007 in Flickr, tagged as "pervasive07." See you at Pervasive 2008 in the land down under at Sydney, Australia!

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