Conferences

Editor: Mary Baker ■ HP Labs ■ mgbaker@hp.com

UbiComp 2003: Sensors in Seattle

Daniel M. Russell

By any name—be it "ubiquitous computing" or "pervasive computing"—there's an interesting niche of computer science that lies at the intersection of systems, human-computer interaction, networking, and communications. You can't define this niche any more clearly than you can define artificial intelligence. The ubicomp field is constantly changing. Not unlike finches on Darwin's Galapagos, it's evolving to incorporate new technologies and trends to better fit into whatever business and scientific climate prevails.

In 2003, the ubicomp crowd met in Seattle—home to some of the biggest software vendors in the US. Yes, it rained. Yes, there was a caffeination of coffee.

And yes, a lot of Microsoft people were there, but they weren't the dominant industrial force at the conference. That award goes to Intel, who seemed to have people in every session, either presenting, hosting, or asking questions. Interestingly, the two universities that seemed to dominate were the University of Washington (no surprise, it's home turf) and the Georgia Institute of Technology. Between the Georgia Tech cyborgs (led by Thad Starner) and smart-home/large-display people (led by Gregory Abowd), the folks from Atlanta put on an impressive show, easily scoring pride of place as most visible ubicomp research program.

TOPICS

The ubicomp community—and there is a strong communal sense—is rich and diverse, as the conference's main themes reflected. Here are some of the key issues and some representative research presented at the conference that struck me as takeaways.

Location and space

Many presenters discussed how to locate people and objects in the world. There were many variations on the theme of using different kinds of widgets and sensors to locate someone or something accurately. The amount of accuracy you can get is a function of how special you're willing to make your environment. If you make a small, heavily instrumented space, you can get good accuracy (plus or minus a couple of centimeters). In the raw, large world, we're still at GPS accuracy (which, in a heavily skyscrapered downtown area such as Seattle, isn't all that great).

Cambridge University is investigating how to make high-resolution spatial models with *bats* (sonar location widgets). As it turns out, with these devices, using building plans isn't detailed enough for reasonable resolution; doing it by hand is currently the only way. The Cambridge researchers have developed a clever ray-tracing technique to improve accuracy.

Microsoft Research's Smart Personal Objects Technology uses wrist-mounted FM receivers that pick up a slow data stream from FM radio but that can also detect multiple sources' signal strength. MS Research is using SPOT to get correct position information at the neighborhood range through Bayesian classification. It's coarse position information, but the method is new and unique.

Modeling and inference

If you're sensing all that information about someone, what can you do with it? Answer: Try to write automated tools to help figure out what that person is or will be doing. This area hasn't seen much development but is obviously hugely relevant. It continues much of the research done elsewhere on multisensor fusion, integrating work from AI.

At the conference, the University of Washington showed their work on developing particle systems for location tracking. The key idea here is that particle systems can model multiple hypotheses about location simultaneously.

Context awareness

Continuing this line of thought, if you have a bunch of sensors, you can group all that data together and call it "context," then use that magic wand to solve all problems. Okay, maybe that's a little too critical. However, researchers are desperately trying to figure out how to use context information, because it's clearly the key to making ubicomp systems do the right thing at the right time in the right place. So far, the ubicomp field hasn't been overwhelmed by all the successes in context awareness. Everyone knows it's going to be useful, but my sense is that we haven't figured out

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how to make it useful. Success here seems to require large amounts of commonsense reasoning, a tough hurdle to place on the path.

Perhaps the most interesting paper in this area was by Louise Barkhuus (Univ. of Copenhagen) and Anind Dey (Intel Labs, Berkeley). They look at three levels of automation that such systems employ, two of which they call "context aware." Not surprisingly, automatic systems that give end users some perceived value are desirable.

Other key players in thinking about context awareness are the University of California, Berkeley, the University of Arhus, and the University of Karlsruhe.

UBICOMP 2003 RAW STATISTICS

- Full name: UbiComp 2003: The Fifth International Conference on Ubiquitous Computing.
- Location: Seattle, Washington.
- Date: 12–15 October 2003.
- 525 attendees (260 US, 58 Japan, 41 UK, 24 Germany, 11 Canada, and so on). 50 percent academic, 50 percent industrial research.
- A single-track conference with 27 full papers (up to 18 pages) and technical notes (up to eight pages). Selected papers appear in Lecture Notes in Computer Science 2864.
- 38 working demos, 42 posters (each demo and poster has a four-page paper), and 13 videos (issued on one DVD).
- 12 workshops and one doctoral symposium (with approximately 200 people).
- No tutorials.
- URL: www.ubicomp.org/ubicomp2003.

New devices and technologies

A particular highlight was in the demo track, where Roel Vertegaal (Queen's Univ., Canada) demonstrated his newest version of a lightweight gaze-detection sensor system. Such devices can tell when you're looking at them by picking up the "red eye" reflection off the back of your eyes. That's a handy bit of context information to know, especially when the device can use that signal productively.

Steve Intille (MIT) has developed a suite of deployable sensors that can serve to instrument a home or office space. A typical deployment involves about 100 sensors, each costing about US$27, and stores time-stamped data at a one-second sample rate. The MIT researchers can then analyze the data for common patterns of behavior done by people inhabiting the instrumented area. That is, the time-stamped information streams can be combined to figure out those patterns of behavior, movement, and so on. Sample sensors include door switches, sensors for sound levels and for light levels, and vibration sensors. Intille and his colleagues have created a nice toolkit and shown vast amounts of collected data, but they haven't yet run studies with this suite as the primary data collection tool. Look for these results at the next conference.

Paul Dietz (Mitsubishi Electric Research Laboratories, Boston) has found that if you reverse-bias an LED, it can *sense* light (as opposed to emitting it). With some very cheap electronics, any LED can become both a data emitter and receiver. It has low bandwidth and works only at short distances—but it's extremely clever.

Mik Lamming (HP) has created Small Personal Everyday Computers, general-purpose small computers (similar to UC Berkeley's motes) with a low-power infrared transmitter-receiver (similar to Charmed technology). SPECs employ back-off strategies for transmitting and receiving that extend power life. Lamming gave some interesting demonstrations of the system's use, including a set of SPECs that mutually support one another in a reminding task. If you pin a SPEC to everything you need to take to school, the flock of SPECs can remind you that you forgot the backpack … with its SPEC.

Georgia Tech showed off a laser pointer device for "selecting" items in the real world. Quite a few of these gadgets were at last year's Ubicomp. The novel idea here is that not only does the pointer select an object, but also a little information is sent back to the pointer, identifying the object selected. This device exhibits a nicely ubicomp-style integration of information flow among devices—the device being pointed at swaps information with the pointer via IR.

And that's one of the big lessons of this Ubicomp conference: Little by little, information-transmitting devices are becoming small enough and cheap enough to build into everything. You can build them into backpacks (SPECs), TVs (pupil detection), any flickering LED, and even laser pointers.

Domestic environments and healthcare

Ethnographic studies of people at home (or in healthcare settings) appear to be popular topics this year. These papers' language sometimes gets overblown ("the movement of design out of the workplace … brings with it the need to develop new analytic concepts to consider how ubiquitous computing might relate to and support everyday activities … and the routines whereby communication is articulated"). But they're all trying to figure out how to best use ubicomp ideas in home settings. In a remarkable coincidence, several studies centered on helping people with cognitive impairments (Alzheimer's and similar). So, there was an interesting and strange session on "how ubicomp helps cognitively impaired people." Who would have guessed that cognitive assistance would become such an application domain for ubicomp?

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Figure 1. While asking the speaker a question, Armando Fox is identified by his RFID tag.

Intel, the University of Nottingham, and Georgia Tech are all players in this arena.

Social aspects

The National Center for Supercomputing Applications demonstrated its IntelliBadge system, which identifies and locates people at a conference. Unfortunately, the user interface was complex, the added value was unclear, and at the same time, Intel was showing off its own RFID (radio frequency identification) badge tricks at the conference (see the "Reactive conference displays" section).

Folks at the Mitsubishi Electric Research Lab showed how people use their DiamondSpin tabletop surface for collaboration tasks. This system implements good tabletop-centric techniques for sharing documents and interoperates well with external laptops.

Sandy Pentland (MIT) talked about tracking sound information from multiple handhelds—multiple iPaq handhelds constantly monitor sound levels, then coordinate what they heard. This approach then analyzes the coordinated sound events to figure out who's near whom, by merging all sound level tracks and looking for correlations. You might not want to give away sound recordings of your life, but if you knew whom you were talking to, and when, would you give away sound-level tracks?

New interfaces

Cambridge University has extended the technique of having computers in a room (or adjacent rooms) communicate via an audio channel. The key is to transmit data at 21 kHz, above where humans can hear but where PCs can do a reasonable job. The Cambridge researchers described schemes for secure transmission, overlaying data atop music (so that your machine can talk to its neighbors by playing a tune out loud). Cute, but will this idea go anywhere?

The IBM Watson Everywhere Displays people showed their latest revision of the hardware and their Java toolkit for placing images (and corresponding sensing of human interaction with the projected images). Their system not only moves the computer display from wall to wall (using servos and mirrors) but also incorporates a computer vision system so that it can see what menu item your finger is touching. This is a good example of how computing can turn anything, even inert walls, into interactive surfaces.

At the other end of the interaction spectrum, Northeastern University has analyzed how much information a user could usefully "read" with a limited number of LEDs. This reductio ad absurdum tests how well a user can decipher one, two, or three flashing LEDs. In many ways, the outcome was obvious—don't make decoding too hard or it gets tough on users. (Morse code works, but people hate it when trying to figure out what's wrong with their computer.) However, this research demonstrates how rigorously you can study such human-interface aspects of ubicomp.

REACTIVE CONFERENCE DISPLAYS

Intel created several reactive displays in various places throughout the conference space. These worked surprisingly well (after some initial bobbles the first day). The displays came in three types:

The first was augmented floor microphones. When a registered attendee who had an RFID tag walked up to the microphone to ask the speaker a question, the large display on the side of the room showed that person's name, picture, and affiliation (see Figure 1). This was almost universally admired because it told you where everyone was from, which many questioners forget to mention. It also worked well for nonnative English speakers or listeners in the hall's less acoustically clean areas.

Second, at one of the coffee tables, while attendees with RFID tags were mixing cream in their coffee, their images appeared on a nearby large display (see Figure 2). The display cycled through each person at the table, showing his or her name, affiliation, and a picture of his or her choosing. To complement my head shot, I chose the picture from my homepage that shows me scuba diving. This was a great icebreaker; when my image came up, the number of conversations that started was impressive.

Figure 2. A reactive display by a coffee table shows Norbert Streitz's photo, name, affiliation, and selected image of a sunset. My name and photo appear on the lower far left (meaning that my name, information, and selected image were the main display a few seconds ago).

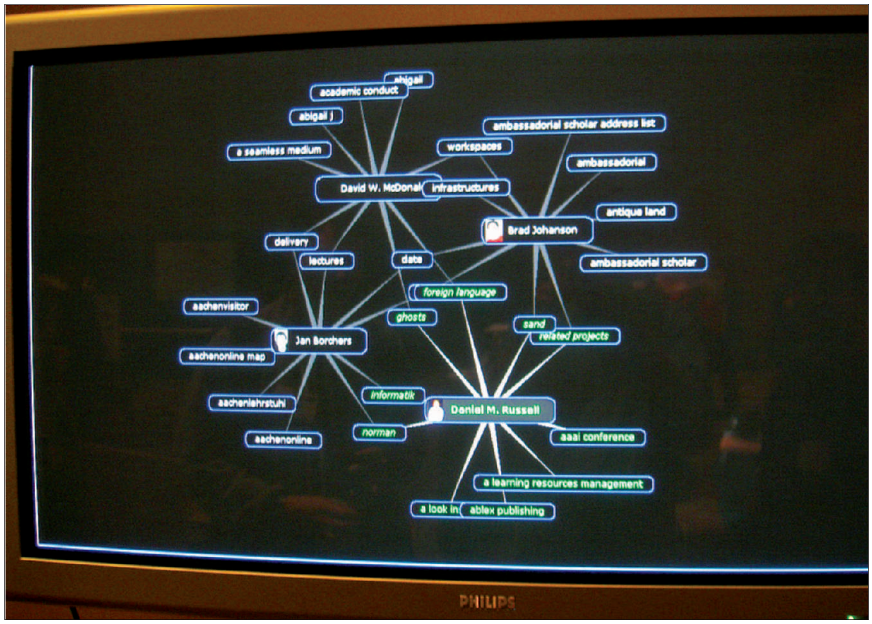

Figure 3. Intel's reactive display shows connections between attendees based on analysis of words and phrases on their homepages.

Third, Intel implemented a "social connectedness" display based on attendees' RFID tags and profiles. As an attendee came within the reader-display's range, a program compared phrases and words on his or her homepage with those on the homepages of one or two other attendees in the immediate vicinity. Then, it drew a "star chart" (a connected graph) to illustrate connected sets of ideas between the attendees (see Figure 3). This was also a big conversation starter, but often the question was "how could it be that you and I have 'red bishops' in common?" Interesting, but not as compelling. However, the idea has potential. Imagine doing this with some real knowledge about people, such as that collected by a social-network-analysis system.

GENERAL OBSERVATIONS

Some of the most interesting aspects of the conference didn't fall neatly into the official themes, but like the conference as a whole, they slip into the spaces between traditional boundaries.

Sensor networks

I saw a lot of interest in the general areas of collecting data from a wide variety of sources (microphones, accelerometers, RFID tags, infrared beams … many, many kinds of sensors). There's a nascent and growing trend in tools and methods to analyze the collected data. Prediction: Next year will be the year of "How the heck do I use this information?" I also expect to see several nice studies of data mining and behavior extraction from many data streams.

Widget heaven

There seemed to be an endless number of sensor widgets, many of which you'd never actually want on your person, but which must scratch some strange electrical engineering itch about building yet another infrared device. These widgets are, on the other hand, becoming increasingly clever. A few years hence, I anticipate small devices that really do provide some useful function. As I noted before, the field is rapidly figuring out how to make everything a data source, channel, and responder. This trend alone is interesting to monitor.

802.11 service nearly everywhere

Open, free, brilliant—every conference should have this. (What will they offer next? Let's hope for printers!) Although some naysayers bemoan that "everyone will just be doing email," I don't think that was the case here. I walked around the back of the conference hall several times informally assessing the number of email clients as the front application (versus note taking or looking up other papers written by the current speaker). Somewhat to my surprise, email didn't dominate—mostly, conferees used the WiFi connection to make themselves smarter in real time by looking up related content.

A blog's unfulfilled promise

There was an attempt to create a realtime blog for the conference as a whole.

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This sounds like a great idea, but in practice (at least this practice) not that much stuff actually got put into it. There was much speculation in the hallways during the breaks about why this was so, but nobody seemed to know. Despite the WiFi network, despite lots of people trying, something made it not work. What? Why? These are questions for next year.

Yhprum's law

This was mentioned several times during the conference—it applies when things work when they shouldn't (the opposite of Murphy's law). As a corollary, things often don't work out the way you'd expect—they work better, especially at the intersection of people and ubiquitously arrayed technology, when people can compensate for the peculiar behavior of systems.

The success of posters and demos

The posters and demo sessions had considerable breadth and depth. They were also extremely well attended and influential, much more so than in most other conferences you might attend. Why? As in real estate, it's location, location, location (and a strong poster program, to be sure)—but the simple fact that the posters were placed in the middle of the events, with the traffic patterns running by them, counts for a lot. Because the conference had only one track, the poster and demos were very close to the main conference room and on the way to wherever attendees were going. Brilliantly, coffee and food was served in the middle of the poster-demo area, so almost all the conferees repeatedly saw the posters. And enough time was set aside so that everyone could actually visit the demos, as opposed to having to decide which talks they weren't going to see. The conference's main track also used a "One-Minute Madness" overview to give everyone a quick shot at each demo and poster.

Ubicomp is a diverse field—systems issues abound, but so do user interfaces and user-friendly approaches to making ubiquitous systems work. The key trends this year seem to be the widespread adoption of RFID tags (which doubtlessly suggests that RFID applications will finally see active deployment in the months ahead), the broadening incursion of data-transmitting devices in the field, and the widespread attempts to build commonplace sensor networks that really can feed interesting data for analysis. Best of all is the distinct trend toward widespread acceptance of ethnographic methods as a way of identifying possibilities and problems in ubiquitous computing settings. Would that other fields could evolve as rapidly toward a humanistic understanding of what their technologies entail. P

Daniel M. Russell is the senior scientist of the User Sciences & Experience Research lab at the IBM Almaden Research Center. Contact him at daniel2@us.ibm.com.