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Pervasive Computing and Environmental Sustainability: Two Conference Workshops

Marcus Foth, Eric Paulos, Christine Satchell, and Paul Dourish

The 2007 Nobel Peace Prize was awarded to Al Gore and the Intergovernmental Panel on Climate Change “for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change.” The citation highlights the fact that information and awareness about causes and implications are necessary but not sufficient to combat climate change. Action is urgently required, and that’s our context: actionable knowledge about the ways pervasive computing and human-computer interaction (HCI) can make a significant contribution to improve sustainability.

No government, industry, or academic community can continue to ignore the issues of environmental conservation and anthropogenic climate change. Compared to the rapid rate that pervasive computing and ubiquitous technology have been developed and integrated into everyday life, applications of technology to improve the ecological situation have lagged behind. This gap in the field is now starting to be populated with relevant R&D outputs that have only recently gained a growing momentum toward establishing critical mass. Some of this work has been presented and discussed in

- the Ubiquitous Sustainability: Technologies for Green Values workshop at Ubicomp 2007,
- the *Cutter IT Journal*’s 2008 issue titled “Can IT Go Green?”
- the *Information, Communication & Society* 2008 issue on information and communications technologies (ICTs) and sustainable development,
- a popular mailing list on sustainable HCI practice (groups.google.com/group/sustainable-chi),
- the Interaction Design for Environmental Information Systems workshop at iEMSs (International Environmental Modeling & Software Society) 08, and
- two 2008 symposia in Kyoto and London organized by the ITU (International Telecommunication Union) on ICTs and climate change.

Continuing this line of work, this *IEEE Pervasive Computing* special issue on environmental sustainability is further evidence of the growing significance and attention this work is attracting.

Additionally, two workshops held at Pervasive 2008 and Ubicomp 08 brought together people who work on pervasive computing and HCI to tackle ecological concerns and use their expertise, skills, and insights to contribute to society’s sustainability and well-being.

PERVASIVE PERSUASIVE TECHNOLOGY AND ENVIRONMENTAL SUSTAINABILITY

The first workshop was held in May 2008 in conjunction with the 6th International Conference on Pervasive Computing (Pervasive 08). About 20 people representing seven countries attended. To maximize time spent on workshop activities, we replaced the conventional paper presentation slots with short 10-minute peer interviews. Each presenter was allocated an interviewer who was asked to read the presenter’s position paper in advance and ask questions at the workshop. This process proved to be engaging and stimulated interesting discussions. In the remainder of the time, the workshop was split into three groups that rotated to work sequentially on the workshop’s three key topics, followed by a plenary discussion.

Three Topics

The call for participation announced the three workshop topics: motivation, ecological impacts, and the digital divide between humans and the environment. The first workshop topic dealt with motivation. The organizers understood that giving people environmental data and educational information might not trigger sufficient motivation to get them

to change their habits toward a more environmentally sustainable lifestyle. The workshop aimed to develop a better understanding of how to go beyond just informing and into motivating and encouraging action and change. Marcus Foth chaired this topic.

Second, pervasiveness can easily turn invasive. It has already caused negative consequences in biological settings (for example, algae in lakes and oceans, kudzu vine in the southeastern US, rabbits and cane toads in Australia). “Pervasive” can be a dangerous term when the ecological impacts are disregarded. Pervasive technology is no different. To avoid further serious damage to the environment, this workshop aimed to lay the foundations to start reconsidering pervasive technology’s impact from an ecological perspective. Eric Paulos chaired this topic.

Third, in terms of the 21st-century “digital divide,” the mass uptake of pervasive technology brings about digitally networked and augmented societies; however, access still isn’t universal. Manuel Castells and others use the notion of the digital divide to account for those whose voices aren’t heard by this technology. Initially, the divide was seen only between the first and third worlds and then between urban and rural, but with today’s near-ubiquitous coverage, the digital divide between humans and the environment needs to be addressed. Virtual environments could give the natural world an opportunity to “speak.” How can we address imbalances? For example, sensors embedded in the environment could let creeks and rivers “blog” their own pollution levels, and let local parks upload images of native bird life. Can the process of “blogging sensor data” (for instance, see <http://sensorbase.org>) help us become more aware of nature’s needs? How can we avoid the downsides? Christine Satchell chaired this topic.

From Brainstorming to Strategizing

In the first round of topic rotations, each group was asked to brainstorm challenges and obstacles that prevent

their particular topic’s goals from being achieved. Participants were asked not to let the limitations of current technology solutions or research findings influence their discussions, but to be guided initially by blue-sky thinking independent of design constraints. In the second phase—after each group handed their topic to the next group—the task was to create and accumulate a variety of potential strategies and scenarios that could meet the topic’s challenges that the group in the previous phase had identified. And finally, after another rotation, the goal was to select one of the identified scenarios and engage in a real-life research study planning exercise with a view to commence and implement work toward realizing and deploying the chosen scenario.

Can reconstructing ourselves as people with sustainable awareness give a voice to the environment?

The following is a brief summary of the deliberations around the third topic, which sought to recontextualize the digital divide as being between humans and the environment. How can the environment have a voice in the real world? What would its digital incarnation look like? How does data get represented? Sensor data requires expert knowledge to make it come to life in digital environments. Challenges were pointed out surrounding agency, voice, who is listening to this voice, and what’s relevant to each person.

We now have real and abundant information about the environment, but what do we do with all the different data sets? In the real world, ecosystems exist in relation to each other. Can we integrate the data we have so that it mimics this ecosystem paradigm? Will this tell us more about the environment and how it’s reacting? Does the virtual make us more distant from what’s really happening? Can we overcome this by

bringing in more of the physical perks into digital relatives? For example, could data collected in real life be incorporated into Second Life (for instance, <http://bpmve.blogspot.com>)?

Can virtual environments allow us to transcend the problems of everyday life? Are we giving the environment a voice by living in more sustainable digital worlds? Can reconstructing ourselves as people with sustainable awareness give a voice to the environment? Could we change behavioral norms such as grooming and cleanliness values through digital environments?

After raising these and other challenges, participants thought of several design scenarios in the second part of the workshop and discussed one specifically in the third part. The distinction between *simulation* and *translation* appeared to be crucial. Simulation communicates the connectivity and interactivity of the elements. It gets people motivated by presenting the environment via spectacle and representing a multiplicity of voices. That way it conveys a sense of urgency and empathy. Translation refers to this question: What is the syntax of the grammar that could give the environment a voice in a way that could be conjoined with our lives? It focuses on the data’s granularity and on ambient, mundane embeddedness in everyday practice.

The group came up with two scenarios representing a living coral reef: one that uses simulation, and the other translation. The first scenario combines live feeds and data-driven models. It starts with a turtle swimming; the user experiences the environment from the turtle’s point of view, borrowing from the cinematic, photographic point-of-view technique to enhance our sense of being there. Viewers get an account of the turtle’s movement. The animals and environment encounter each other. As each interaction takes place, the point of view changes, and we’re presented with each object’s experience. We begin to get a sense of the greater ecosystem. The temporality and rhythm shifts are

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apparent for a fuller appreciation of the environment.

The second scenario is a translation of a single element of a living coral reef, which might involve an indicator of water quality. Water can't tell us itself if it's polluted, so we're translating it. Sensor chips in a pond in a public space might glow red, representing increasing water pollution. It's an ambient representation that we can integrate in an everyday environment.

UBIQUITOUS SUSTAINABILITY: CITIZEN SCIENCE AND ACTIVISM

The second workshop was held in conjunction with the 10th International Conference on Ubiquitous Computing (UbiComp '08) in September in Seoul, South Korea. This was a smaller workshop, with about 10 people attending, which made for a highly interactive and engaging discussion throughout the day. This workshop's focus was on citizen science as a way to enable a participatory urbanism. Eric Paulos, R.J. Honicky, and Ben Hooker proposed that

We need to expand our perceptions of our mobile phone as simply a communication tool and celebrate them in their new role as personal measurement instruments capable of sensing our natural environment and empowering collective action through everyday grassroots citizen science across blocks, neighborhoods, cities, and nations.

Although sensor-rich ubiquitous computing devices have ushered in a compelling series of new device usage models that place individuals in positions of influence and control over their urban lives, there are a number of important barriers to the development and adoption of such systems. These research challenges formed the topics of interest for this workshop, including socialite

to citizen—redefining identity, feedback loops, privacy and anonymity, calibration and do-it-yourself culture, sensor selection, and environmental impact.

During the workshop's discussions, four challenges and issues emerged. First, activism and voice raised questions about strategies for prioritizing areas of action and having a voice and being heard, especially regarding the impact on democratic decision-making processes. What role can the products of our design research play as tools to organize and facilitate activism? And, do we want citizens to become scientists, or science to be more accessible to citizens? Second, considering our research activity's goals, aims, and outcomes, how do we ensure we're

What role can the products of our design research play as tools to organize and facilitate activism?

designing for positive social change? What role can seductive and playful approaches play as a way to provide motivation and incentive (for instance, pollution levels influencing the mood of music playlists)? What mechanisms can translate virtual activity into real-world action (such as getting a real tree planted)? Third, in terms of desirable design attributes to work toward, participants flagged as key such criteria as being approachable, accessible, agile, usable, and useful as well as the need for local and sociocultural contextualization, privacy, and security. And fourth, with regard to data, one of the most prolific areas of work surrounds the meaningful visualization of data streams. This then requires smart techniques to measure and collect credible data, compare and convert it, ensure simple portability and exchange of accounts and data between platforms, and support up and down scalability.

In addition to these four areas that

might inform a set of programs for a future research agenda, workshop participants raised bigger-picture questions and issues, such as the role of government and industry support and endorsement and the role of policies that distinguish between climate change mitigation and adaptation. Also, what will be the "academy" of citizen scientists, and how will it generate justified belief, knowledge, and science? People argued that generic sustainability goals need to be unpacked, contextualized, and questioned, because an increase in efficiency doesn't reduce or conserve resources per se. This would then require a cultural value shift from "sacrifice" to "lifestyle choice." It would also require "green HCI" to overcome the hippie image and become sustainable itself, rather than remain a fad or "one-workshop-wonder," as an attendee put it.

The enthusiasm around our workshops underscores not only the depth of interest in these topics but also the diversity of approaches that currently motivate pervasive computing research in these areas and the opportunities for pervasive computing research to make a difference. From the discussions that emerged, we can identify several potentially fruitful areas for future work.

The first is movement from individual to collective representations. Many—although certainly not all—of the applications in this area so far have focused on individuals' actions. Understanding collective action is considerably harder and is an area that needs attention. Several problems arise when we start to do this, including being able to see the individual's actions in the broader context, and the need to design to encourage participation rather than showing people how their actions fall short of those of others or of some ideal. Nonetheless, this area holds much promise—for instance, in the area of public displays and urban screens.

A second, related consideration is the need to move beyond applications that, as Phoebe Sengers noted in a panel at CHI 08, turn environmental responsibility into issues of personal moral choice, frequently at the point of consumption (for example, in the supermarket). Enlightened and ethical shopping practices are certainly part of a broad solution. However, as James O'Connor notes in his book *Natural Causes*, the primacy of market models and the focus on individual responsibility can obscure the political and economic factors at work in debates about sustainability. My personal decisions in the supermarket might be highly consequential, but so too are my decisions in the ballot booth and the decisions of elected representatives and corporate board members. Making room for politics is an extension of the pervasive computing research agenda that applies in many areas (including transportation policy and privacy regulation) but is perhaps particularly pressing in the area of environmental sustainability.

The third opportunity we want to draw attention to is the opportunity to focus on issues of scale. Many of the systems and applications presented at our workshops ran on mobile phones or incorporated other mobile devices, and it's in the nature of mobile devices that they move around in the world. These movements enable not simply comparisons of place-to-place, but of scale-to-scale. Understanding how environmental issues operate at scale—how regions are interconnected and how global issues, regional issues, and local issues are connected—is a challenging problem for any attempt to make people more conscious of the questions of sustainability. A major opportunity, then, is to exploit the mobility and pervasiveness of our infrastructures and applications to make issues of scale more visible for people in the course of everyday interaction.

We're pleased to see a growing community forming around topics at the intersection of pervasive computing

and environmental sustainability, and the lively, engaged discussion at our workshops evidences the potential that this research holds on scales both large and small. ■

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The Pervasive '08 workshop was organized by Marcus Foth and Christine Satchell, Queensland University of Technology, Australia; Eric Paulos, formerly with Intel and now with Carnegie Mellon University; Tom Igoe, New York University; and Carlo Ratti and Francesco Calabrese, MIT. Papers are available on the workshop Web site at www.urbaninformatics.net/green. Christine, Eric, and Marcus thank Adrian Lahoud, University of Technology Sydney, for the opportunity to present a summary of the workshop discussions in a lecture as part of the Atmospheric Urbanism Roundtable 2 on 22 May '08 at UTS.

The UbiComp '08 workshop was organized by Eric Paulos; Marcus Foth; Christine Satchell; Younghui Kim, Hongik University in South Korea; Paul Dourish, University of California, Irvine; Jaz Heejeong Choi, Queensland University of Technology. Papers are available on the workshop Web site at www.urban-atmospheres.net/Ubicomp2008.

Marcus Foth is a senior research fellow in the Creative Industries Faculty at Queensland University of Technology. Contact him at m.foth@qut.edu.au.



Eric Paulos is an assistant professor in the Human-Computer Interaction Institute at Carnegie Mellon University. Contact him at eric@paulos.net.



Christine Satchell is a senior research fellow in the Creative Industries Faculty at Queensland University of Technology. Contact her at christine.satchell@qut.edu.au.



Paul Dourish is a professor of informatics in the Donald Bren School of Information and Computer Sciences at the University of California, Irvine. Contact him at jpd@ics.uci.edu.



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