

Pervasive Computing and Environmental Sustainability

A report on two related conference workshops

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Introduction

The Nobel Peace Prize 2007 was awarded to Al Gore and the Intergovernmental Panel on Climate Change (IPCC) “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 urgency that information and awareness about causes and implications are necessary but not sufficient to combat climate change. Action is required, and that is in our context, actionable knowledge about the ways pervasive computing and human-computer interaction can make a significant contribution to improve sustainability.

Environmental conservation and anthropogenic climate change are issues that can no longer be ignored by any government, industry or academic community. 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 research and development outputs that have only recently gained a growing momentum towards establishing critical mass. Some of this work has been presented and discussed at the workshop on *Ubiquitous Sustainability: Technologies for Green Values* at UbiComp 2007, in a 2008 issue on *Can IT go green?* in the Cutter IT journal, a 2008 issue on *ICTs & Sustainable Development* in *Information, Communication & Society*, on a busy and popular mailing list on sustainable human-computer interaction practice (groups.google.com/group/sustainable-chi), a workshop on *Interaction Design for Environmental Information Systems* at iEMSs 2008, and two 2008 symposia in Kyoto and London organised by the ITU on *ICTs and Climate Change*. Continuing this line of work, this present special issue on *Environmental Sustainability* of IEEE Pervasive Computing is further evidence of the growing significance and attention this work is attracting.

Additionally and in response to these challenges, two workshops were held at Pervasive 2008 and UbiComp 2008 to bring together people that are part of this growing number of researchers working on pervasive computing and human-computer interaction to tackle ecological concerns and utilise their expertise, skills and insights to contribute to sustainability and the well-being of society.

Pervasive Persuasive Technology and Environmental Sustainability

The first workshop was held in conjunction with the 6th International Conference on Pervasive Computing (Pervasive 2008) on May, 19th, 2008, in Sydney, Australia. It was attended by about 20 people representing seven different countries. To maximise time spent on workshop activities, we replaced the conventional paper presentation slots with short 10 min peer interviews. Each presenter was allocated an interviewer who was asked to read their workshop position paper in advance and ask questions on the day. This process proved to be very 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 three key topics of the workshop, followed by a plenary discussion. The three topics that were announced in the call for participation are as follows:

First, providing people with environmental data and educational information – via mass communications such as film, TV and print and new media, or micro communications such as pervasive sensor networks (e.g., Participatory Urbanism and Ergo at urban-atmospheres.net; real-time Rome at senseable.mit.edu; biomapping.net;

placeengine.com) – may not trigger sufficient motivation to get people to change their habits towards a more environmentally sustainable lifestyle. This workshop sought to develop a better understanding how to go beyond just informing and into motivating and encouraging action and change. This topic was chaired by Marcus Foth.

Second, pervasiveness can easily turn invasive. It has already caused negative consequences in biological settings (e.g., 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. In order to avoid further serious damage to the environment, this workshop aimed to lay the foundations to start re-considering the impact of pervasive technology from an ecological perspective. This topic was chaired by Eric Paulos.

Third, addressing the 21st century Digital Divide: The mass uptake of pervasive technology brings about digitally networked and augmented societies; however, access is still not universal. Castells and others use the notion of the ‘digital divide’ to account for those whose voices are not 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 allow creeks and rivers to blog their own pollution levels, local parks can upload images of native bird life. Can the process of ‘blogging sensor data’ (e.g., sensorbase.org) assist us in becoming more aware of the needs of nature? How can we avoid the downsides? This topic was chaired by Christine Satchell.

In the first round of topic rotations, each group was asked to brainstorm challenges and obstacles that prevent the goals of their particular topic to be achieved. Participants were asked not to allow their discussions to be influenced (yet) by the limitations of current technology solutions or research findings, but to be initially guided 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 challenges of the topic that the previous 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 towards realising and deploying the chosen scenario.

The following is a brief summary of the deliberations around the third topic that sought to re-contextualise 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 is relevant to each person.

We now have real and abundant information about the environment, but what do we do with 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 is really happening? Can this be overcome by bringing in more of the physical perks into digital relatives? For example, data collected in real life could be incorporated into Second Life?

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? Is the environment given a voice by our reconstruction of ourselves as people with sustainable awareness? Could we change behavioral norms such as grooming and cleanliness values through digital environments?

In response to these and other challenges that were raised by participants, a number of design scenarios were thought of in the second part of the workshop, and one specifically discussed in the third part. The distinction between simulation and translation appeared to be crucial. Simulation communicates the connectivity and the 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 the 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 granularity of the data 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 its point of view, borrowing from the cinematic, photographic point of view technique to enhance our sense of being there. We are provided with 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 are presented with the experience of each object. We begin to get a sense of the greater ecosystem. The temporality and rhythm shifts are apparent for a fuller appreciation of the environment.

The second scenario is a translation of a single element of a living coral reef. It may involve an indicator of water quality. Water cannot tell us itself if it is polluted so we are translating it. Sensor chips in a pond in a public space may glow red, representing increasing water pollution. It is an ambient representation that can be integrated in an everyday environment.

Ubiquitous Sustainability: Citizen Science & Activism

The second workshop was held in conjunction with the 10th International Conference on Ubiquitous Computing (UbiComp 2008) on Sep, 21st, 2008, 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. The focus of this workshop was on citizen science as a way to enable a participatory urbanism. Eric Paulos and his team propose 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.” While sensor rich ubiquitous computing devices usher in a compelling series of new device usage models that place individuals in the position of influence and control over their urban life, 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 and included topics such as

- From Socialite to Citizen: Redefining Identity
- Feedback Loops
- Privacy and Anonymity
- Calibration and DIY Culture
- Sensor Selection
- Environmental Impact

During the workshop’s discussions four broad themes of challenges and issues emerged. First, activism and voice raised questions relating to strategies to prioritise areas of action and to have a voice and be heard, especially with regards to the impact on democratic decision making processes. What role can the products of our design research play as tools to organise and facilitate activism? And, do we want citizens to become scientists, or science to be more accessible to citizens? Second, considering the goals, aims and outcomes of our research activity, how do we ensure we are designing for positive social change? What role could seductive and ludic approaches play as a way to provide motivation and incentive (e.g., pollution levels influence music playlists)? What mechanisms are feasible to translate virtual activity into real-world action (e.g., a real tree is planted)? Third, in terms of desirable design attributes to work towards, criteria such as, approachable, accessible, agile, usable and useful were flagged as key, as well as obviously the need for local and socio-cultural contextualisation, privacy and security. And fourth, with regards to data, one of the most prolific areas of work surrounds the meaningful visualisation 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 as well as up and down scalability.

In addition to these four areas that may inform a set of programs for a future research agenda, bigger picture questions and issues were raised, such as the role of government and industry support and endorsement, and the role of policies that distinguish between climate change mitigation versus adaptation. As well, what will be the ‘academy’ of citizen scientists and how does it generate justified belief, knowledge and science? It was argued that generic sustainability goals need to be unpacked, contextualised and questioned. An increase in efficiency does not reduce or conserve resources per se. This would then require a cultural value shift from ‘sacrifice’ to ‘lifestyle

choice'. And this would also require 'Green HCI' to overcome the hippie image and become sustainable itself rather than a fad or 'one-workshop-wonder' as it was put.

Conclusions

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 a movement from individual to collective representations. Many – although certainly not all – of the applications in this area to date focus on the actions of individuals. Understanding collective action is considerably more difficult, and is an area that needs attention. Several problems arise when we start to do this, including being able to see the actions of the individual 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, particularly perhaps in connection with interests in public display and “urban screens.”

A second, related consideration is the need to move beyond applications that, as Phoebe Sengers noted in a panel at CHI 2008, turn environmental responsibility into issues of personal moral choice, frequently at the point of consumption (e.g. in the supermarket). Enlightened and ethical shopping practices are certainly part of a broad solution, but, as James O'Connor notes in his book “Natural Causes,” the primary 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 may be highly consequential, but so too are my decisions in the ballot booth, or 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 to which we would draw attention 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 is in the nature of mobile devices that they move around in the world. These movements allow 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 are pleased to see a growing community forming around topics at the intersection of pervasive computing and environmental sustainability, and the lively and engaged discussion at our workshops evidences the potential that this research holds on scales both large and small.

Acknowledgements

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The Pervasive 2008 workshop was organised 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 website at <http://www.urbaninformatics.net/green/>. Christine, Eric and Marcus thank Adrian Lahoud, University of Technology Sydney (UTS), for the opportunity to present a summary of the workshop discussions in a lecture as part of the *Atmospheric Urbanism Roundtable 2* on May, 22nd, 2008, at UTS.

The UbiComp 2008 workshop was organised by Eric Paulos; Marcus Foth; Christine Satchell; Younghui Kim, Hongik University, South Korea; Paul Dourish, UC Irvine; Jaz Hee-jeong Choi, Queensland University of Technology. Papers are available on the workshop website at <http://www.urban-atmospheres.net/Ubicomp2008/>

We thank all participants for their contributions. We apologise for any potential errors or omissions in how the workshops' discussions are represented here.