Workshop on

Pervasive Persuasive Technology and Environmental Sustainability

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PERVASIVE PERSUASIVE TECHNOLOGY AND ENVIRONMENTAL SUSTAINABILITY

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Abstract

Environmental sustainability and climate change are issues which must no longer be ignored by anyone, any industry or any academic community. The pervasive technology, ubiquitous computing and HCI community is slowly waking up to these global concerns. The key theme of this workshop around environmental sustainability will be addressed threefold: (1) How to go beyond just informing and into motivating and encouraging action and change. (2) Pervasiveness can easily turn invasive. We want to start re-considering the impact of pervasive technology from an ecological perspective. (3) Digital divide between humans and the environment: Can the process of 'blogging sensor data' assist us in becoming more aware of the needs of nature? How can we avoid the downsides?

1. Theme of the workshop and topics of interest

Environmental sustainability and climate change are issues which must no longer be ignored by anyone, any industry or any academic community. The pervasive technology, ubiquitous computing and HCI community is slowly waking up to these global concerns.

The Nobel Peace Price 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 of the fact that information and awareness around causes and implications are necessary but not sufficient to combat climate change. Action is required.

The key theme of this workshop around environmental sustainability will be addressed threefold:

1. 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 (cf. 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 seeks to develop a better understanding how to go beyond just informing and into motivating and encouraging action and change.
2. 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 aims to lay the foundations to start re-considering the impact of pervasive technology from an ecological perspective.

3. 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' (sensorbase.org) assist us in becoming more aware of the needs of nature? How can we avoid the downsides?

2. Topics of interest

Topics of interest include but are not limited to:

- Transfer persuasive and motivational approaches and experiences from design cases which successfully employ pervasive technology in areas such as games and entertainment, health, and marketing and advertising, e.g., competition, collaboration, rewards, team play, make it fun.
- Innovative ways or re-appropriated ways to reduce the impact of computing production (e.g., increase the life cycles of computing devices; re-purpose older computing devices for sensor networks, data logging and other low-performance but increasingly useful tasks; re-think the design of computing devices to allow for more efficient and thorough recycling of components).
- Considerations of what 'pervasive technology' means from an ecological perspective.
- New applications of pervasive computing technology to support environmental education and decision making in formal (school, work) and informal (leisure, play, everyday) settings.
- Evaluations and evaluation methods for assessing the impact of pervasive computing devices, applications on the environment.
- New interfaces of pervasive computing devices, systems and applications and modes of interactions between people and nature.

3. Format

After the introduction of the organisers and the key themes of the workshop, we will do a little icebreaker activity in the form of mini interviews followed by brief informal peer introductions of all participants. We then want to generate a common knowledge base for the workshop on environmental sustainability by collecting information on what we know about the issues at hand, e.g., sources of data on climate change, accessibility and legibility of that data, current impact it has or lack thereof. After morning tea, the workshop breaks into three rotating groups (starting with 1/2/3) according to the three themes: 1. Motivation, 2. Ecological impact, and 3. Digital divide between humans and the environment. After lunch, these groups rotate themes so each group works on each theme: 2/3/1, followed by 3/1/2. Following afternoon tea, we hold a plenary to share results and discuss further steps, plan the Design Challenge 2009, discuss collaboration arrangements beyond the workshop and allocate tasks to volunteers.

Design Challenge 2009: Impact! In addition to the conventional academic outcomes, we want to define a number of feasible goals and design a process to bring these goals to fruition within 12 months time and present them at Pervasive 2009. Additionally, we want the workshop to be an opportunity to exchange research insights, expertise and ideas. We also want to leave enough breakout and social time to allow for professional networking opportunities.

4. The organisers

Marcus Foth: ARC Australian Postdoctoral Fellow, Institute for Creative Industries and Innovation, Queensland University of Technology, Brisbane, Australia and 2007 Visiting Fellow, Oxford Internet Institute, UK. Interests: urban informatics, master-planned communities, social computing, social networks, triple bottom line sustainability, wombats. urbaninformatics.net

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5. A selection of relevant readings

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Notes on the Political Image:
Pervasive Computing, Modeling Assemblage, and Ecological Governance

Abstract:

What are the larger opportunities for pervasive computing technologies to monitor and model the intricate assemblages of the natural and artificial environments? Perhaps more importantly, how might such media contribute to or even constitute in a new kind of *reflexive governance* in the image of the information they produce?

We consider what is at stake for such a constitution by locating it in theoretical insights from other contexts. In outlining current and future research directions, we underscore the necessity of environmentally produced information to concretize itself not merely as data for some later, deferred political action, but as a direct political image: an *instrumental diagram* in its own right.

Agencies: Borders, Sensors, Interfaces Far from borderless, our world is filled with an apparent infinity of political borders , biological borders, logistical borders, informational borders. “Things” (flora, fauna, and machines, data) assemble, expunge and express themselves within this segmented landscape.

We see such borders also as *interfaces*, membranes which govern the conditions of exchange between any paired complex bodies (from ambient air and soil to a bank customer and her money.)

An environmental sensor, be it a flower petal or inscribed silicon wafers microcasting in near-field communication, is, in Bruno Latour’s parlance, a kind of *actant*. (Latour, 2005) It speaks on behalf of some condition in this little network and communicates to other parts of the system. The interface, in this case that sensor, thus takes the position of a limited agent in the whole system, and in it, the smallest transactional unit of data, becomes itself the emergent actor in this landscape of borders.

The Pervasive Scenario: To Govern What? The driving scenario understood by us, is one in which there would be a local administration of each interface’s expression -- what toxins flowers absorb, what plastics are allowed through customs, what concrete infrastructure cracks under slow pressure—based on what is heard and is relayed through a pervasive network of networks of computational monitoring media.

But once data is gathered what does this image look like in detail, and what is done with it once we have it?

Individual events in this listening landscape are absorbed as signifiers, are correlated according to as yet unimagined protocols, and are registered not only as information about which a governance might act, but for us as the actual medium of some non-governmental political apparatuses would register themselves back onto the world.

That is, first the information is a map or diagram and then, more interestingly, that same information becomes an interface.

In this, governance is not delivered by the management of "human rights," but instead acts according to new constitutional forms, yet to be formally ratified. Its work is not simply policing an environmental homeostasis, but of direct management by participation of ecosystemic interfaces *as the constitution of a new polis and politics.* (Mouffe, 2005)

It is that imminent political diagram, not yet present, that redefines interfaces less as pure information than as positions in an expanded parliamentary territory; neither a 'standing reserve' of objective datapoints nor a undifferentiated naturalized unity. (Heidegger, 1993)

Policy and Relationality At NYU's Environmental Health Clinic, these operations are designed as a matter of institutional policy (or policy is made as a matter of design.) They are a model for how ecological interfaces, both human and non-human, both organic and inorganic, can be understood as site of *health*. And health is then less the individual body and the medicines that might be inserted into it to contain undesirable states, than it is the external, plural, at-hand living and non-living worlds of the urban landscape. Here a fertile middle-ground is taken as the location of prescription and operation. The individual lung and the gathering storm system are engaged at once by design, as both public health records in their ways.

Both provide an open form of evidence of what the administrative unit and ecological microcosm that is NYU is doing and has done through its multi-scalar participations in the urban ecology of the city. As with any Clinic, at EHC prescriptions are given. But here prescriptions are offered both to individuals and to architectural systems on how to better monitor and adjust or redesign the causal interrelationships in which they work.

Some Recent Projects Toward This: A Portfolio of Prescriptions Some projects at NYU's EHC work to monitor and measure that evidence, and others to redesign through it.

For example, One Tree Project, in which genetically identical trees were planted across the Bay Area acts as a formidable monitoring interface for the effects of ambient environmental variation on the complex mechanisms of organic growth. In another,, 1400 face masks were distributed to the mingling hordes of protesters and pedestrians during the Republican convention in New York, which together worked as a networked surface on which individual consumption of air pollutants was traced and tracked. In these, distributed interfaces express and even compute, socially legible evidence of ecological interactions. But instead of such symptoms rendered through a mediating layer of silicon computation, these simple, extremely analog devices draw their evidence more directly.

This allows a more direct experiential response to the information they express, but like any such image they require another step before becoming instruments of change and governance.

Other NYU EHC projects directly redesign the *assemblages* at work (DeLanda, 2006). No Park, for example, uses a legal gap in traffic storage interfaces (i.e. no parking zones in front of hydrants) to install intricately designed gardens which absorb automobile related pollutants right where they are generated. Here the socio-ecological network of the city is neither smothered nor rarified, but amplified and engaged by configuring it at the level (and height) of collective assembly.

Future projects seek to engage at the scale of the NYU micro-city and its architectures. One locates solar panels not on rooftops but as window shades, circumventing the difficult regulations of solar collection technologies in Manhattan as well as locating the production side of shared energy infrastructure at the direct personal level of individual dorm and office dwellers. He and she can see and relate to their energy consumption footprint at the literal scale of his or her own footprint. Another improves on the vogue for rooftop gardens as decorative micro-parks for people and turns them into gray water treatment machines that support the interlocking purposes of ground-level and migratory species across the city.

Data Smog and the Missing Expert In these projects a problem of translation and activation is introduced, one that is not solved by the amassing of more computational power and the scattering of sensors into the world. That is, natural systems work very well already as monitoring devices, but we have yet to formulate complete constitutional images of their participation. We have yet to find the best ways of making an *image-instrument* of their political profiles, diagrams of their evidence that constitute an effective agency.

Scaled somewhere between the medical care of the individual body and the continental sweep weather modeling , the an ecological *polis* is largely unmanaged and unarticulated.

To introduce an layer of engineered listening and speaking media into and onto the ambient environment (in parking lots, wetlands, cloud clusters, lung cells, etc.) will open a flood of information about how worldly systems perform and relate. By flipping the on-switch, as it were, and being at once able to monitor and model the interrelationships of all assemblages at once, would be akin to the invention of the microscope, opening up the complexity and agency of worlds we could not imagine.

But would it also be a din of voices that we simply do not have the means to properly listen to, to govern through: a churning cacophony of signals?

The design impulse will be to model these signals into dataclouds, undulating traffic clusters that allow datasets to be sliced and figured by different patterns and variables. We believe that such data clouds have purpose and potential but cannot by themselves realize either. Dataclouds have a tendency to inappropriately reassure their audiences. They imply, in the grace and intricacy of their renderings, a presumed expert system (and expert) on whose behalf they are fictitiously designed who *must* be using these information as an instrument of government, somewhere. If not now, soon. Dataclouds signify control but too often only defer agency to that missing expert. This is part of the work that they do as blog culture memes. They assure; they present the *affect* of a political agency that is still to find its bearings.

The data cloud looks like expert instrumentation, but does the closed frame of its bounded diagnostic, in fact make it easier for those viewing the data cloud to retract their own involvement back into logic of simulation and to remain spectators?

What is the political space of air quality? What would it mean for such images to work more effectively as interfaces? How can the images of evidence, produced by pervasive sensing media, work not just to display information about socio-ecosystmes but to turn their audiences into users who can, in the direct course of their habitation of the world, compute by their interactions a preferred assemblage of what the image represents? How can the data that becomes diagrams, become again instruments of a new political space?

The answer to these, we believe, lies in the specification of both an ecologically appropriate political scale and a constitutional image of that *polis*, which in turn may *rely on the encounters between pervasive computing and ecological governance.*

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Author Biographies

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THE POTENTIAL OF UBICOMP TECHNOLOGIES TO DETERMINE THE CARBON FOOTPRINTS OF PRODUCTS

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Abstract

Several problems exist in accurately quantifying the greenhouse gases (GHG) which result from the production, transportation, usage, and recycling of products. We review in this paper the current attempts at measuring GHG emissions and investigate the potential of UbiComp technologies in improving the state of the art in carbon footprint calculation and in communicating the result to consumers. This has potential benefits on consumer awareness and behaviour and can also foster competition among companies towards higher energy and resource efficiency.

1. Introduction

Companies measure energy usage and greenhouse gas (GHG) emissions to comply with regulations, to assess their performance in an energy-constrained economy, and to participate in a growing carbon market [8] Moreover, some organizations also identified the value of communicating the carbon footprint[1] of their products to end consumers who increasingly consider environmental aspects in their purchasing decisions [4]. However, a number of challenges need to be addressed when determining GHG emissions for individual products or services. In particular, it is difficult to capture all relevant emissions along the product's lifecycle and to account for the variations in footprints of individual instances of products, such as spatial, temporal, and supplier variations. In this contribution, we propose a solution that leverages UbiComp technologies in order to dynamically track a product's carbon footprint along its life-cycle and make it easily accessible to the consumer. The benefit of such a solution is that it enables comparisons on many levels, for example between variations of the same product, between products from different manufacturers, and between different companies upstream in the value chain. Consumers can then exert pressure by selecting the least carbon-intensive products. We provide a review of methods used to measure GHG emissions in section 2 and outline in section 3 where UbiComp technologies can help. We conclude in section 4.

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[1] "The carbon footprint is a measure of the total amount of CO_2 emissions that is directly and indirectly accumulated over the life stages of a product."[11]

2. State of the art in measuring energy usage and GHG emissions

We review in this section the approaches used to determine the emissions of companies (supply side) and tools that calculate emissions due to the consumption by individuals (demand side).

2.1. Supply-side approaches

There are several standards and guidelines used by companies in order to quantify and report their GHG emissions. The most prominent standard is the GHG corporate protocol [8], used by the majority of the FT500 companies and serving as the basis for most GHG guidelines and programs. This protocol is accompanied by tools that help companies to calculate their emissions. Various other tools exist in the context of GHG reporting programs such as CARROT for participants in the California Climate Action Registry [3] and SEIT which is provided with the DoE 1605b voluntary reporting program [6]. Furthermore, software vendors offer enterprise solutions for carbon and energy management, e.g. Environmental Compliance by SAP [9].

There has recently been some effort to calculate the carbon footprint of some particular products using a supply-chain-wide approach. Prominent examples are the pilots conducted by Carbon Trust together with brands such as Walkers and Trinity Mirror [4]. Furthermore, CarbonCounted provides an online application for brand owners, also for the purpose of calculating a product's footprint [5]. These two examples differ in many aspects which makes it impossible to accurately calculate and compare a product's footprint, such as whether they include all GHG emissions or only CO_2 and whether they consider offsets. They do not take the energy usage at the retailer into consideration, or do so in a very coarse-grained way. Neither takes home usage into account. These issues make it impossible to accurately calculate and compare a product's footprint. Finally, when different suppliers have different footprints, or when there are temporal or spatial variances between different instances of a product, average numbers are used, which results in inaccurate results. Examples include fruits bought off-season which require six months of chilled storage or products being shipped half way across the globe.

2.2. Demand-side Approaches

Many carbon calculators are available to determine the carbon footprint of an individual or a household. According to Bottrill [1], the calculators give an annual result based on one data entry per activity, thus not taking seasonal or lifestyle fluctuations into consideration. The author adds that the tools are falling short of accurately monitoring people's energy use and providing the feedback required. In the field of monitoring energy usage, there are several projects that provide accurate numbers by conducting measurements on household devices. For example, Kuckuck is a project which uses sensor data to display domestic energy consumption [10]. The Device-Level Power Monitoring system [7] comprises monitoring units that plug into power outlets enabling per-device electricity monitoring. Despite such projects that measure the energy usage of different devices at home, this usage is not meant to be attributed to the products that require them, for example the energy used by a washing machine or a refrigerator is not distributed, respectively, among the clothes and foods inside. In effect, the energy usage at home cannot be accumulated to the total carbon footprint of a product which until now is focusing only on the supply-side calculations. In the next section we will describe how products can have one dynamic carbon footprint which is easily accessible to users.

3. The potential of UbiComp

To calculate a dynamic carbon footprint, we need a mechanism that links information about emissions with the products that required them, namely by assigning to each item its share of the emissions of each emitting process. This can be achieved via the unique identification of items, e.g. via the Electronic Product Code (EPC) [2]. Items with an EPC number can be tracked from manufacturing along the supply chain and until the retailers, with the possibility to add dynamic information – such as the carbon emitted at each partner – to the EPC Information Services (EPC IS). With unique identification in place, the share of yet-disregarded life-cycle stages of the product's footprint can be quantified and attributed to the items that required them. For example, the same EPC number can be used to identify items beyond the point of sale, where intelligent devices can attribute their consumed energy to the items using it. Unique identification can also make the product footprint easily accessible, e.g. to a consumer on his mobile phone. After including all the product life-cycle stages, we would be able to consolidate the emissions and assign them to individual items or other entities. This approach therefore comprises two stages. The first stage is an information gathering stage that can be realized by a publish/subscribe system in which process owners publish the process information and users (including items) can be subscribed to the processes they are part of. The second stage is an on-demand calculation of an item's footprint based on the available process/item information. Our initial research indicates that only minor changes are necessary to use EPC Information Systems for the purpose of carbon footprint management.

4. Conclusion

We reviewed in this paper the available approaches in measuring GHG emissions and noted their shortcomings in contributing to the accurate quantification of carbon footprints of products. We then highlighted the potential of UbiComp technologies in contributing to this effort. Such technologies can also make the carbon footprint of products conveniently accessible to consumers. This enables consumers to exert pressure on the brand owner to decrease the footprint and it helps influence their own behavior at home in order to keep the footprint as low as possible. Also, if companies can compare the carbon-intensity of products from different suppliers, they can exert pressure by selecting partners with the least carbon-intensive products.

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Motivation

This paper comprised a brief review of measures to calculate carbon emissions and possible ways to make carbon footprints more accurate by including the various product lifecycle stages. Since our focus is on providing the consumers with the appropriate information to empower them in the decision-making process, the key question is which information consumers need, how to retrieve it, and how consumers will be influenced by it. Also important is the optimal medium and form of presenting the information and how to measure their feedback including possible third-order effects. We are eager to discuss such questions in the workshop and learn from others' experiences. More information about us and other related research can be found at www.bits-to-energy.ch.

Authors' Biographies

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Towards Participatory Design of Ambient Persuasive Technology

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1. Design Problem and Method

At my institution, the EcoCampus committee is charged with developing approaches to promote sustainable behavior on campus, specifically behaviors that will reduce the campus's net carbon emissions. Approaches that provide new opportunities, such as coordinating a campus rummage sale to reduce end-of-year trash disposal and start-of-year purchases, have met with great success. More direct approaches to persuade individuals to change their behavior—for example, posting pleas against food waste and reminders to turn off lights—have had less clear results, and even engendered some resentment.

I aim to engage this committee and others in participatory design of new persuasive technology aimed at changing these types of behaviors in ways that are more demonstrably effective, and engaging rather than annoying. Participatory Design (or PD) is a family of theories and methods related to end users as full participants in the design process. Many, but not all, PD researchers and practicioners are motivated in part by a belief in the value of democracy in the design setting [12]. Participatory design is well-suited to this design context because my institution has a culture of active stakeholder involvement in decision-making, and because there is a group of people already committed to environmental sustainability. I believe it is only right to include them in the design process. By making them full participants, I gain access to their special knowledge, perspectives, and creativity, as well as an enthusiastic group of supporters of the new approaches.

The design process will begin with a Future Workshop [9, 10] to guide EcoCampus committee members and other interested members of the community in generating visions for behavioral and cultural change on campus. A Future Workshop consists of three phases: a Critique phase to elicit problems with current practice, a Fantasy phase to envision an ideal world in which those problems were solved, and an Implementation phase in which the aim is to begin making plans for realistic changes. Whereas most Future Workshops in the PD literature have focused on work practices, the workshop concept originated in the context of community organizing around societal issues [9]; the topic of this workshop will be "Green Culture at Grinnell." At the end of this workshop, I hope we will have identified a number of behaviors to target for change, as well as possible approaches—technological and non-technological—for changing them. I plan to continue working with a smaller group of stakeholders on one or more behaviors that seem appropriate to the development of persuasive technology.

2. Ambient Persuasion

Designing technology to change behavior with respect to environmental sustainability, or to promote sustainable culture, clearly falls into B.J. Fogg's definition of persuasive technology: "interactive computing systems designed to change people's attitudes and behaviors" [4, p. 1]. Indeed, Fogg uses the example of paper recycling by an organization to illustrate his different perspectives on the roles of persuasive technology [3]. Several efforts have begun to explore persuasive technology in relation to environmental sustainability. For example, RideNow is a web- and email-based system that facilitates ad-hoc ride sharing [15]. The SmartTrip tool for mobile devices simplifies the task of combining multiple errands into a single trip, with the goal of reducing driving among those resistant to ride sharing or public transit [8]. GreenScanner is a mobile application that shoppers can use at the store to read reviews of the environmental impacts of various products [14]. In these systems, the computer's functional role is that of a persuasive tool [3, 4]: The system makes suggestions, provides information, or makes the desired behavior easier to do. But, users must go to some effort to adopt these tools. As Fogg argues, persuasive technology for mobile devices are most effective when they help people to achieve the goals they have already decided upon [4, pp. 192–3].

An alternative is to embed persuasive tools in the built environment, particularly in public or semi-public places. The idea is to make suggestions at exactly the right time and place, without annoying those to be persuaded [4, 11, 7]. Recent work by Mathew and his students exploits this approach, which he calls *environmental persuasion* [11], in the context of promoting physical activity. In one design, an attractive glass staircase with embedded information displays entices commuters in a subway station to use the stairs rather than the escalator [11]. In another, information kiosks at bus stops suggest that walking will result in earlier arrival time at the destination than waiting for the bus, and will burn more calories [13]. Embedding persuasive technology in public spaces allows for *incremental peruasion*: "Persuasion is initiated by the persuasive elements, but the actual behavior change is a result of gradual but increasing awareness of the importance of that change" [11]. Such an approach can influence the behavior of those who are not initially committed to behavior change. This gradual approach also leaves room for discovery, playfulness, ambiguity, and subtlety, qualities that could make a persuasive device intriguing rather than annoying.

Some design efforts have already begun to explore environmental persuasion with respect to environmental sustainability. For example, WaterBot aims to reduce water consumption by tracking and displaying information about water use at the sink itself [1]. Although the design is aimed at the home or workplace, some ideas could be adapted to sinks in more public spaces. Intriguingly, Holstius et al. use live and robotic plants in an ambient display that shows the balance between trash and recycling in a dining area [5]. The goals of ambient displays—to provide awareness through the physical environment, without demanding attention [16]—seem particularly compatible with the idea of non-annoying, incremental persuasion. These initial efforts show this area, which one might call *ambient persuasive technology*, is ripe for further investigation.

3. Research Questions

I believe that applying participatory design to persuasive technology is a novel approach. Futhermore, as Hornecker et al. argue, the application of participatory design methods to the design space of pervasive computing is still largely unexplored [6]. A key question, then, is how (or whether) to incorporate known principles and guidelines for the design of persuasive technology and for persuasion in general, such as Cialdini's six fundamental human tendencies [2], with the process of participatory design. A second question is how to incorporate concern for the ethics of persuasion into the process. Design participants are not the only ones who will interact with the persuasive technology, and they are not necessarily typical stakeholders as they almost certainly value environmental sustainability more highly than most community members. Fogg outlines a method to account for ethical concerns in the design of persuasive technology [4], with which participants might be engaged. Furthermore, although participatory design is not inherently problematic from the standpoint of environmental sustainability, can particular design themselves be made more sensitive to that goal?

WaterBot [1] and the "infotropism" display [5] not only make indirect suggestions, but also monitor and report on behavior in the surrounding environment. Because of the community context, such displays tread a fine line between self-monitoring, which seems generally positive and acceptable, and surveillance, which Fogg warns may cause public compliance without private acceptance [4, p. 49]. What design features are needed to avoid that undesirable outcome? What guidance can I draw from these examples? For example, where WaterBot aims to support social validation in a household context by tracking the water consumption of individuals, the infotropism display, designed for a more public context, does not connect the data it gathers with particular individuals.

Fogg argues that behavioral change is a more compelling metric than attitudinal change for measuring the success of persuasive technology: it is thought to be more difficult to achieve, it can be measured without relying on self-reports, and finally, it is a direct measure of real-world outcomes [3]. However, following the work of Holstius, et al. [5] and other work on ambient displays, and consistent with the goal of not annoying people, it will be important to assess users' attitudes towards and understanding of the persuasive technology itself. In the context of environmental sustainability, one should also ask about the net environmental impact of the persuasive technology. Unlike applications for mobile devices already in use, such as cell phones, ambient persuasive technology involves introducing new devices into the environment and thus involves some measurable consumption of resources—electricity to power the device and other resources for its manufacture. Can we demonstrate that the devices we build have an environmental impact that is lesser than that of the undesirable behavior they are intended to change? What techniques can we use to reduce the power consumption of ambient displays, both in the prototype phase and in deployment? At one extreme, we might eschew the "technology" aspect of persuasive technology altogether, and use Intille's approach of temporarily deploying sensor systems to measure the behavioral impacts of low-technology persuasive techniques [7].

4. Motivation for Attending the Workshop

I have been interested in environmental sustainability and ambient displays for several years; the theme of "Persuasive Pervasive Technology and Environmental Sustainability" lets me bring those interests together. At the workshop, I hope to meet other researchers interested in related areas and perhaps raise some different perspectives on design methodology. I hope also for feedback and new insights to guide my work, which is in its earliest phases.

5. Biography

Janet Davis is Assistant Professor of Computer Science at Grinnell College, a socially-conscious liberal arts college in central Iowa. She earned her B.S. in Computer Science at Harvey Mudd College, and her Ph.D. in Computer Science and Engineering at the University of Washington. Her dissertation work involved the design of new user interfaces for a large-scale urban simulation system, with a particular attention to the values of democracy and freedom from bias. She is a member of the Sustainable CHI group. Her interests include Value Sensitive Design, Participatory Design, ambient displays, environmental sustainability, design for local impact, and alpacas.

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Motivating Environmentally Sustainable Behavior Changes with a Virtual Polar Bear

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Abstract

Personal choices and activities directly account for much of the energy consumption in the U.S. with secondary impacts of those activities influencing an even larger proportion of energy consumption. Although there is a long history of investigation into motivators for energy-conservation, it is still unclear how to encourage persistent behavior change, and technology has only recently been applied to the problem. In this study we sought to learn if virtual pets could have a positive impact on real-world, environmentally responsible behavior. The polar bear is a powerful iconic symbol for many individuals, and its fate can be simply and directly connected to environmentally responsible behavior. Just as Tamagotchis evoked a powerful response from their owners, we hoped to use attachment to a virtual polar bear as a motivator for energy conservation. We ran a study exploring the impact of attachment on real-world actions. The results of our study suggest that an interactive virtual polar bear may increase environmentally responsible behaviors, especially when emotional attachment takes place.

1. Introduction

Global warming continues to be one of the world's major issues. In the U.S. alone, Americans consumed 100 quadrillion BTUs of energy in 2005 [11], with personal, individual activities accounting for much of this consumption. For example, 40% of the energy consumed is used for residential or commercial lighting, heating and cooling. All of this is driven directly by individual choices or indirectly because of consumer needs. Thus, personal choices can lead to a significant reduction in energy consumption, with a corresponding reduction in the release of CO_2, one of the primary gases responsible for climate change. However, this requires persuading individuals to change their behavior, and maintain those changes over time, both difficult propositions. Our approach is to leverage the power of the polar bear as a symbol of climate change by creating a virtual pet, a technology that has promise for supporting behavior change (e.g. [7]). We describe a pilot study showing that increased attachment to a virtual polar bear had a significant positive impact on the number of actions that individuals had taken as reported a week after they used our software. This work is currently being incorporated into a mobile tool intended to influence transportation choices and into a social networking website.

There is extensive literature in the areas of environmental sociology, public policy, and more recently, conservation psychology that discusses the promotion of environmentally responsible behavior. In past work, we have explored the impact of motivators such as public commitment, frequent feedback, and personalization on environmentally responsible behavior [10]. Research in conservation psychology implies that animals help humans connect with nature [9]. Vining's literature review demonstrates the extensive evidence for strong emotional bonds between humans and animals but she states that the answer to whether caring about animals or the environment leads to environmentally responsible behavior remains open [12]. Technology may provide a mechanism for leveraging these bonds to encourage behavior change. For example, Tamagotchis are virtual pets requiring nurturing interaction in order to be sustained. This in turn led to an emotional attachment to these virtual pets, for example owners mourned when their pets "died" [2]. Lin and Strub's "Fish'n'Steps" study is an example of how an interactive computer game using a virtual pet, in this case fish, encourage physical activity [7].

Our approach integrates conservation psychology, a study which looks into relationships between nature and humans, with persuasive technology, the study of how computers can leverage psychological cues to motivate and influence behavior [3]. For example, motivators of environmentally responsible behavior are more effective when they have a direct impact on people's needs or concerns [1]. Also, caring for *real* animals can inspire conservation behavior [12]. In this paper we show that an emotional connection to a *virtual* pet that responds to environmental behavior can help motivate an individual by making that behavior seem to directly impact an individual's concerns.

2. Experiment

We conducted a one week, between subjects study to explore the effect of higher attachment to a virtual pet (the *attachment group)* to lower attachment to the same pet (the *control group)* on environmentally responsible behavior. To create attachment, we used a story describing environmental change, specifically the impact of climate change on the habitat of polar bears, pre-tested to elicit sadness. We asked participants in the attachment group to read it, reflect on their emotions and write about environmental responsibility, and name the polar bear on their display.

Figure 1: (top) a polar bear with lots of ice (bottom) a polar bear with little ice

Participants were shown a Flash-based virtual polar bear on an ice floe that would grow as they committed to environmentally responsible actions and decrease as they chose not to commit to actions. As shown in Figure 1, the size of the ice floe would change depending on the number of actions a subject committed to taking. Our study tested the following hypotheses:

- H_1: Commitments - Users who form emotional attachment to the virtual polar bear will commit to more environmentally responsible actions than users who do not form bonds
- H_2: Fulfilled Commitments - Users who form emotional attachment to the virtual polar bear will fulfill (act on) their commitments

- H_3: Donations - Users who form emotional attachment to the virtual polar bear will donate more to a zoo than those from the control group

We recruited 20 subjects (10 in each condition) associated with local universities. Participants were given $15 and a shower timer for their time. All participants completed an initial survey at the start of the experiment to test whether either group was more likely to have higher motives for environmentally responsible behavior and whether this changed during the experiment. We used a subset of questions from De Young's scales measuring competence and participation [1]. Participants also completed two additional scales both before and after the main intervention (interacting with the polar bear): the first measured levels of care on agreeableness and empathy [5] and the second measured overall environmental concerns [6]. All scales had a reliability of .65 or higher, measured using Cronbach's α (values were α=.8615 for competence, α=.8920 for participation, α=.7579 for care and α=.655 for environmental concern).

1	Turn off the water while brushing your teeth
2	Turn off lights if you are leaving a room for more than 10 minutes
3	Wash only full loads of clothes
4	Wash only full loads of dishes
5	Dry only full loads of clothes
6	Carpool 1 day a week when you would otherwise drive
7	Pledge to ride the bus 1 day a week when you would otherwise drive
8	Combine trips in vehicle (i.e., visit multiple destinations on one trip)
9	Take the stairs instead of the elevator a minimum of 5 times per week
10	Take a shower instead of a bath
11	Restrict length of shower to 5 minutes
12	Use a low wattage night light
13	Lower heating thermostat to 68 degrees and wear warmer clothes
14	Unplug any electronic devices when not in use
15	Take an environmental sustainability flyer and give it to a friend

Table 1 - List of Actions

The actions are included in Table 1. Fourteen were taken from sixty actions previously designed and tested as part of a field study of the StepGreen website [10]. We created an additional action, "Take an environmental sustainability flyer and give it to a friend," and made flyers available to participants.

3. Results and Discussion

Out of the 20 participants, 60% were male and 40% female; 95% of the participants were students. Out of the 20 participants, 19 completed the first task; we reached 11 to ask about donations (5 control, 6 attachment), and we were only able to reach 11 participants to ask which actions they fulfilled (5 control, 6 attachment). The initial survey showed balance across the groups in terms of motivation for environmentally responsible behavior (p=.08833 and .08199).

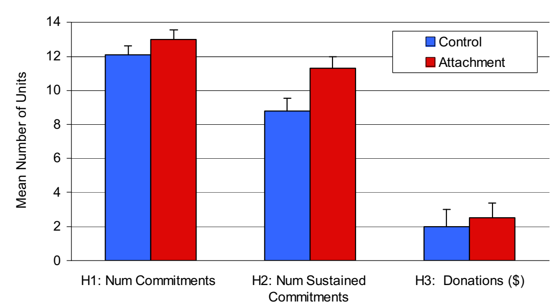

Figure 2: (above) The attachment graph was higher for all hypotheses, and H_2 (Fulfilled Commitments) is significant ($F[1,11]=6.527$, $p=.0309$).

As shown in Figure 2, participants in the attachment group had a higher mean number of committed actions (H_1), fulfilled commitments (H_2) and a higher mean donation (H_3). Of these, the difference in fulfilled commitments was statistically significant: $F[1,11]=6.527$, $p=.0309^*$. The attachment group also demonstrated significantly greater environmental concern and greater care after reading about and interacting with the polar bear ($F[1,19]=5.1273$, $p=0.0369^*$ and $F[1,19]=3.8124$, $p=.0675$, respectively).

Our findings demonstrate that participants in the attachment group were more concerned about the environment, and this translated directly into significantly higher reported actions. Of particular interest is the fact that while there was not a significant difference in the number of commitments between the groups, reported follow through in terms of fulfilling those commitments was significantly higher. However, it is possible that participants in the attachment group lied about their follow through out of guilt or some other emotion. Also, we do not know how long these differences will be sustained.

4. Future Work

Our next step is to deploy the polar bear over a longer period of time, in a setting where we can objectively measure its impact on action. This addresses the two biggest concerns mentioned above. We plan to deploy the polar bear on a mobile platform that can track use of different transportation options. Additionally, we are currently creating a virtual polar bear plugin for MySpace and Facebook. The large numbers of users on sites such as MySpace (used by over 61.2 million unique visitors) and Facebook (over 19.5 million unique users)[8] presents exciting opportunities to encourage personally- and socially-desirable change in behaviors. Users will be able to publicly make commitments and have the status of their polar bear on display. Based on consistency theory, users would be more likely to behave consistently with their commitment [4]. This may also lead to further research on the impact peer pressure may have on environmentally sustainable actions.

5. Reason for Attending

The work we described is an initial contribution to the issue of persuading individuals to take more sustainable actions. As such, it addresses one of the three main topics of the workshop, how to motivate sustainable action. Additionally, though there was no room to discuss it here, our research is expanding to address the appropriate deployment platforms and messaging for varied socio-economic and ethnic groups. We are excited by the opportunity to attend this workshop and engage researchers on these critical fronts.

6. Author Bios

Tawanna Dillahunt is a first year Ph.D. student at Carnegie Mellon University. Her research interests include environmental sustainability and pervasive computing.

Geof Becker works at the Tepper School of Business at Carnegie Mellon in Marketing and Public Relations and is interested in encouraging development of online communities that commit to positive social action.

Jennifer Mankoff is an assistant professor at CMU in the HCII. Her research interests include environmental sustainability, pervasive computing, and Assistive Technologies.

Robert Kraut is a Herbert A. Simon Professor of HCI at CMU. He conducts research in four major areas: online communities, everyday use of the Internet, Technology and conversation, collaboration in small work groups, and computers in organizations.

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Points of Persuasion:

Strategic Essentialism and Environmental Sustainability

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Abstract

The environmental movement, as a political body, is an alliance of many different groups with different agendas and goals, not always compatible. Nonetheless, as a matter of political pragmatism, the identification of "the environment" as a common focus binds these actors together – an act of strategic essentialism. Drawing on this observation and on an account of identity production in social software, I suggest that an alternative approach to pervasive persuasion might be to help crystallize this sort of political connection.

1. Strategic Essentialism and Sustainability

Postcolonial scholar Gayatri Spivak (1987) coined the term "strategic essentialism" to refer to the ways in which subordinate or marginalized social groups may temporarily put aside local differences in order to forge a sense of collective identity through which they band together in political movements. Post-war resistance movements to colonial rule often relied on just such mechanisms by which particular forms of ethnicity or nation-hood were used to align disparate groups towards common goals. Spivak's observation is that, while such terms as "indigenous" peoples or similar labels result in problematic and unstable groupings that erase significant differences and distinctions (rethinking colonial categories), nonetheless these acts of identity formation support important political ends. So while terms such as "Indian," "African", or "Native American" may be manufactured and suppress highly significant differences, they nonetheless do important work.

Studies of the social history of environmentalism show much the same sort of process at work in the development of the environmental movement. Cronon (1995) documents the history of our conception of Wilderness. In the period of the Western Expansion, wilderness is a threat to human existence. It betokens the kinds of arid, unforgiving and hostile environment that settlers might experience in their movement west, something that must be conquered (and so also a source of opportunity.) It is not for nothing, he argues, that it is the wilderness where Christ struggles with the Devil, or into which Adam and Eve are cast. By the late nineteenth century, though, a new notion of wilderness has emerged – not a threat but a comfort, not something to be overcome but something to be cherished, a place not of danger but of rejuvenation. The national park movement reflects a change in the understanding of what wilderness might be, what it might be worth, and why. Cronon documents a range of considerations that are part of this ideological reframing of wilderness (including the gender issues associated with the image of the rugged masculinity involved in taming "virgin" nature, the problems of habitation by indigenous peoples, and the issues of the supernatural associated with the encounter with wilderness), but his central concern is the way that the ideological construction of wilderness obscures the central role of human action:

> By imagining that our true home is in the wilderness, we forgive ourselves the homes we actually inhabit. In its flight from history, in its siren song of escape, in its reproduction of the dangerous dualism that sets human beings outside of nature—in all of these ways, wilderness poses a serious threat to responsible environmentalism at the end of the twentieth century. (Cronon, 1995:81).

More broadly, as Proctor (1998) also demonstrates, strategic essentialism lies at the heart of the creation of the environmental movement at all. What we think of as environmentalism is a political force resulting from the forging of an alliance between groups with concerns as diverse as open access, biodiversity, air and water pollution, surfing, animal husbandry, agricultural efficiency, bioengineering, and rock climbing. "The environment" emerges as a concept shaped by the union of common interests, even though these interests might be mobilized in quite different ways and for quite different reasons. As Spivak would note, the inherent heterogeneity of the group is made subservient to strategic goals. Arguably, one of the reasons that the clash of perspectives over environmentalism – between, for instance, Western environmentalists and native Amazonians over sustainability and economic survival in the rainforest (Tsing, 2004) – are so troubling is because they threaten the unstable alliances out of which these political movements are formed.

2. Pervasive Persuasion

When we talk of persuasion as a consideration for information technologies, we are frequently concerned with how behavior modification can be induced by intervening in moments of local decision-making and by providing people with new rewards and new motivations for desirable behaviors (Fogg, 2003). These kinds of strategies have been common, for instance, in health and fitness applications (e.g. Lin et al., 2006). One might imagine a range of pervasive persuasive technologies along these lines. If we argue that the essential importance of pervasiveness is that the technology accompanies people in the course of their everyday lives, then technologies that help people to assess their everyday actions in terms of broader questions of sustainability present themselves – applications that help people understand their carbon footprint, for example, or ones that provide access to environmental information as a part of shopping (e.g. Bernheim-Brush et al., 2004).

However, if we think about environmental sustainability from a political perspective, and particularly bearing in mind the important role of strategic essentialism, then a different application area presents itself. From this perspective, what we might want to persuade people of is the ways in which their interests are aligned with those of others. As is demonstrated by sociological research into the formation of social movements, this process of alignment and mobilization, by which one can start to find one's own interests as being congruent with those of others, is a critical first step in political mobilization (Snow et al., 1986).

Arguably, we can find the foundations for such technologies in the current crop of so-called "social software" applications, of which Facebook is perhaps currently the most prominent. Social networking sites claim simply to articulate social networks that are already there, but of course, social networks in the formal sense are an analytic device rather than an aspect of our own everyday experience. (This can most easily be demonstrated by asking the question, "Tell me about someone two hops away from you in your social network." Nobody can, since, by definition, such a person is not known to the subject.) Instead, then, we can approach social networking sites as technologies of affiliation, alignment, and identification, sites at which forms of collective identity are forged and enacted.

If social software works by, first, tying individuals and actions to groups and networks and, second, by providing a platform through which one acts as a member of a group (be that an institutional affiliation, an informal group, or simply a identifiable social type), then a similar approach can perhaps be harnessed in the domain of sustainability. This would suggest that, rather than using technology to provoke reflection on environmental impact of individual actions, we might use it instead to show how particular actions or concerns link one into a broader coalition of concerned citizens, social groups, and organizations. So, for instance, if we were to combine the sorts of monitoring technologies developed by Paulos (2008) or the kinds of scanning technologies explored by Bernheim-Brush et al. (2004) with social networking accounts of the different interests associated with sustainability debates and movements, then we might have a system that could tell people, "the action you are about to take aligns you with X but against Y," or, "the products that you are looking at have these different impacts on these different groups." What is being done here is a process of frame bridging (Snow et al., 1986) that not only allows for forms of reflection and behaviour modification but also links the individual into a broader coalition of interests. What becomes visible is not so much the world, but its political alignments.

3. Conclusions

Various attempts have been made to use pervasive technologies to connect people to the environment in which they live (e.g. Paulos, 2008), or to provide them with tools for reflection on the impacts of their practices (e.g. Bernheim-Brush et al, 2004). Observing that we need to think about sustainability also as a process of political mobilization, I have suggested that we can draw too on a different set of technologies – the social networking technologies familiar from Web 2.0 applications – as a means to connect people not only to environments and to actions but to other people; and, moreover, to do this in a way that helps them to see their way through the central questions around which political action might be initiated. The new goal of pervasive technology here, then, is to promote a form of strategic essentialism that is part of this process.

4. Acknowledgements

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Motivation for attending: I'd like to understand the ways in which environmental questions act as a nexus for technological, social, and cultural considerations, and are likely to develop over the next few years.

Understanding motivation and enabling action towards change

Penny Hagen, Duncan Underwood[1]

Abstract
Social Technologies can be platforms for change as they facilitate actions and act as spaces for conversation and the dissemination of information. In this workshop paper we explore the concept of motivation in relation to our practice as technology designers. We are specifically interested in what motivates people to take action, and how we can support that as technology designers.

We frame our conversation about motivation, technology, and action towards sustainability by exploring two aspects of our design practice. The first aspect focuses on design research and using participatory methods such as Mobile Diaries to understand what motivates people to be involved, to take action, to contribute. The second aspect is the design of technologies, channels or tools that enable people to act upon their motivations effectively. We provide examples of this through case studies of our work.

1. Digital Eskimo and our stakeholders

Digital Eskimo is a design agency with a commitment to working on projects we consider to be progressing humanity towards a nurturing (more than sustainable) way of being. To achieve this we practice ‘Considered Design’. This definition covers a number of aspects of how we approach our design and underlying company philosophy.

It means we are ethics and values driven. The act of doing design is meaningful to us, over and above the notion of monetary profit. Our practice is grounded in, and informed by the principles of sustainability. We think that change is produced collectively, created through action, experience and sharing knowledge. And we think design can make a difference.

Our clients are equally invested in social change and are often activists themselves, existing to promote or facilitate environmental or social causes. Many of our clients are non-government organisations and workers unions. Similarly the stakeholders, users or community members that we are designing for are also (often) interested in change - seeking action or ways to complete action. Our work talks to their motivations and interests. Some of our work focuses on creating and growing existing communities over time, some of our work focuses on

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capturing focused action one time, on a large scale. Our work is underwritten by an approach to design that focuses on understanding what motivates people to take action or be part of a community towards change.

While our core work is manifest in online technologies, it increasingly takes the form of more integrated services across multiple delivery systems, overlapping with ubiquitous and pervasive systems. Through the workshop we hope to explore how our approach to design can be applicable to pervasive systems, and contribute to expanding discourse on how we as designers we can build pervasive technologies that support or motivate sustainable living practices.

2. An approach to design

Our work is guided by the traditions of Participatory Design [2][7], in that we recognize the expertise of the users and stakeholders, what Sanders calls a Participatory Mindset [6]. For these reasons we select research methods based on their ability to immerse the design team in the world of our stakeholders, methods that facilitate a collaborative relationship with clients and aim to enable all stakeholders to be appropriately represented in the design. We use participatory methods such as workshops and collaborative brainstorming and we build collective personas and scenarios with our stakeholders [3]. While we continue to employ a range of researcher driven methods such as interviews, focus groups, surveys and questionnaires we embrace methods that are more designerly (e.g. [1]) participatory (e.g. [8]) and interventionist (e.g. [5]) such as Mobile Diaries [4].

In this paper we briefly present three diverse "social technology" case studies where actions or discourse are facilitated through technology. The first is a Design Research case study using technology to understand underlying attitudes to sustainability as well as ways to support corresponding actions. The second and third, an Integrated Campaign and an Online Campaign site respectively both aim to motivate and facilitate change by using technology to amplify individual actions on a collective platform, albeit in quite different ways.

3. Case studies

3.1 WWF Human Habitat Diaries (Design Research Project)

Digital Eskimo conducted a research project with five participants over a two week period. Each was selected from one of the different demographic groups likely to interact with WWF's FutureMakers project. The intention was to provide a window into the lives of participants, a way for them to share their world with us, and their perspective on it. This research was to inform the design of online tools that enabled and encouraged such sharing between people on an ongoing basis.

Participants were prompted to reflect their environment and daily lives from a sustainability perspective and were invited to implement one of eight measures that would reduce their negative impacts on the environment. Participants used Mobile Diaries which include camera phones, low resolution video cameras, maps and notebooks to record their daily experiences at work and at home. SMS's and images with audio annotations were sent from the phone to personal Habitat Diaries (password protected blogsites) assigned to each participant that could be accessed by the participants and the designers/researchers. The notebooks, video cameras and maps were mailed back to us at the conclusion of the study. Combined, they enabled us to develop a rich picture of the participants' lives, habits, and attitudes to sustainability. The data gathered enabled us to understand the participants motivations around issues of sustainability, the obstacles motivated people faced in making change, as well as identify when and why they might be motivated to participate in an online community focused on supporting change.

3.2 David Hicks – Amnesty International Australia (Design Case Study)

In this case study Digital Eskimo was asked to develop an online facility to promote a project of Amnesty International Australia (AIA), raising awareness of the issue of David Hicks' imprisonment without trial in Guantanamo Bay.

AIA had built a full sized replica of the cell David Hicks lived in and the public were invited to spend a small amount of time in the cell alone to consider David's experience in Guantanamo Bay and the broader issue of his ongoing imprisonment. We saw an opportunity to use the online space to show and share people's reaction to their time in the cell as well as their attitude on the issue by placing a webcam in the cell that enabled visitors to record a 30 second message to camera that was then syndicated to one or more websites. The corresponding website enabled people who could not access the cell to understand a little of the experience, at the same time by broadcasting these messages we affected a far broader audience than would have originally have been reached.

Digital Eskimo's response to this opportunity promoted the tour of the cell and communicated AIA's campaign objectives. But furthermore it allowed people to act upon their motivation to do something about these issues: voice their opinion on the issues of David Hicks' detention and the imprisonment of terror suspects without trial; to hear the opinions and responses of others to their experience in the cell; and to share their own views among their networks.

3.3 ACTU Your Rights at Work campaign site

The website is the hub of the ACTU's 150000 member campaign against the unpopular WorkChoices legislation. Our team designed the site with an emphasis on informing workers and inspiring specific targeted action.

The site delivers the ACTU's information in a simple and effective style, as well as telling the stories of workers who have been affected by the WorkChoices legislation. Primarily however the site is a campaigning tool that was designed to deliver single strong calls to action that can be updated by the ACTU at a moments notice.

This tool allowed the ACTU to easily and quickly communicate to their member base. It enabled motivated people to undertake a collective action and to easily promote such action to their friends and networks, amplifying the call to act and directing such activity in order to maximize its effect.

4.0 Conclusion

Digital Eskimo is a design agency that utilizes social technologies to promote and progress a nurturing (more than sustainable) way of life. Key to our own motivation within our projects is that we share the goals of our clients. Key to achieving successful design outcomes is developing a richer understanding of the motivations of each project's stakeholders and our ability to design technologies that encourage and enable people to act upon these motivations; connecting, sharing knowledge and working together to create change towards a nurturing / sustainable life.

5.0 Biography

5.1 Penny Hagen

Penny Hagen is the Executive Producer at Digital Eskimo. Prior to joining Digital Eskimo Penny spent 10 years freelancing as a producer, designer and trainer specializing in interactive media and community projects in Sydney and New Zealand. Penny has also worked as a researcher for UTS's Interaction Design Lab investigating mobile technology use and conducting research into social software and participatory design methods. Underlying her approach to technology design is a commitment to creating communication tools that acknowledge the emergent nature of social networks and encouraging appropriation by the people that use them.

5.2 Duncan Underwood

Duncan Underwood is the Sustainable Development Manager at Digital Eskimo. Duncan graduated with a Bachelor of Design (Industrial) from UTS in 1997 and is currently enrolled in Master of Social Science (International Urban and Environmental Management) at RMIT. Before Digital Eskimo, Duncan worked in business development at Clean Up Australia.

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THE NEW WELL-TEMPERED ENVIRONMENT: TUNING BUILDINGS AND CITIES

Dan Hill & Duncan Wilson

Abstract: Our work has two main components - one part practical, the other theoretical - though both are related, and have developed in discussion. They both concern the measurement and feedback of energy usage in buildings, and then cities, in order to enable users to change their behaviour - to in effect, 'tune' their environment. The work is intended to raise important questions about the efficacy of such schemes, outline the potential of systems when stretched over urban and social networks, to speculate about the future of information as part of the fabric of buildings, and to make some practical considerations clear along the way.

1: Tuning 13 Fitzroy Street

The first part of the work concerns research and development work led by Arup's Dr. Duncan Wilson, deploying wireless sensor networks in the new Arup building at 13 Fitzroy Street, London.

This is predicated on the emerging understanding that occupation of a commercial building typically costs more than 200 times the initial capital cost of construction and that ~40% of final energy consumption in the European Community is in the buildings sector. In addition governments are pushing regulatory frameworks to reduce the energy impact of such running costs [1]. Within the UK, energy used in buildings accounts for some 50 per cent of the country's carbon dioxide emissions.

Thus the ability to moderate the use of energy in buildings can have a significant impact on the overall efficiency of the built stock. Changes to the design and construction of new buildings is leading to significant improvements in building efficiency but the majority of the built stock is comprised of older buildings with limited potential for passive energy saving. The Living Buildings initiative [2] at Arup is one example of our sustainability activities working towards the consequences of the context above. At a macro level we are also working at a city scale on projects such as Dongtan eco-city in China [3]. But what are the opportunities for pervasive computing?

We have been exploring the use of ubiquitous or pervasive computing technology based around wireless sensor network (WSN) platforms to gain improved understanding of real-time operation of buildings and to allow greater environmental control of existing buildings that do not have the installed infrastructure to actively control energy consumption.

The first small steps have been to deploy WSN's in the office environment to investigate both energy consumption of the building and the comfort of the space [4]. Various quantitative and qualitative measures are being taken and fed back in real-time to occupants of the space (not just building / facility managers). At the newly built Fitzroy Street building, the two main sensor network development platforms used were Crossbow and Arduino. Motes have been deployed throughout the building (and in a related study at Central Saint Martins college in London), connecting over Bluetooth IEEE 802.15 and sensing occupancy levels (via Passive InfraRed sensors) combined with performance data from the building management system. The Bricks Framework is used to fuse data together, and provide the base for dynamic visualisations, sound installations and interactive devices.

We'll discuss various methods for conveying information back to users, and the many issues therein. As it stands, the system is producing data across all axes and various visualisation methods are being designed for a number of locations within the building.

Ultimately, this work at the level of buildings may provide an opportunity to start doing city wide monitoring of the pre- and post-occupancy performance of sustainable buildings. This pervasive data collection from very large sensor populations could be integrated to support control and optimisation at this scale. City information modelling systems are beginning to emerge, extrapolating from Arup's work with building informational modelling (BIM), and this provides a unique opportunity for post construction analysis and validation.

2: The Personal Well-Tempered Environment

Developed by Dan Hill, this section continues the themes covered thus far, extrapolating the potential for such schemes when stretched across urban and social networks. It's an imagined system at this point [5], a real-time dashboard for buildings, neighbourhoods, and the city, focused on conveying the energy flow in and out of spaces, centred around the behaviour of individuals and groups within buildings.

In this, it becomes a form of 'BIM 2.0' that gives users of buildings both the real-time and longitudinal information they need to help change their behaviour and thus use buildings, and energy, more effectively. It would be an ongoing post-occupancy evaluation for the building, the neighbourhood and the city. Importantly, it proposes measuring contribution as well as consumption, through sensors embedded into localised wind and solar power, grey-water collection, and so on. Further, it explores the idea of measuring behaviour across wider circuits, such as an individual's movement through the city (scoring 'points' for public transport versus private transport, monitoring environmental usage in office environments, and so on.)

Suggested as a software service layer for connecting things together within and across buildings, it would take a 'plug-in' approach to connecting energy sources and resources, drawing from architectural theory of Archigram and Cedric Price amongst others. Multi-sensory feedback is a particular theme in the suggested interface, exploring different ways of conveying this information. The work is based on a survey of existing energy monitoring schemes and products in this area, collated and discussed online. Over and above this, it folds in some ideas from social software, particularly the reflexive mode produced by systems such as Last FM, Flickr, Dopplr, Nike+ and so on, and wraps these up with the aforementioned architectural theory as well as making connections to newer concepts like Bruce Sterling's spimes and everyday product design.

Drawing from this recent history of social software, the proposal describes various ways in which an 'open' approach to data, allied with social networks, may enable a socialising of the data, or even a 'gaming' element - in which individuals, suburbs, neighbourhoods and cities can compare their environmental performance. This latter aspect is an attempt to make the civic relationship between an individual and their environment clear, thus addressing a key issue in the emerging informational city. Taking the conceptual starting point of an API on a house, the idea suggests extending this to the API on the neighbourhood, even the city itself. Making the effects of informational behaviour visible on the street in turn asks further questions about how to perceive and communicate the emerging informational aspects of the contemporary city, a theme increasingly fundamental to urban planning.

Though initial investigations elsewhere suggest that feedback on energy use can help change behaviour [6], questions will be asked of the efficacy of such 'persuasive visualisation', as part of a critical assessment of whether such systems can truly have a beneficial effect in terms of 'tuning the environment', or whether the real problems lie elsewhere.

The connection to the aforementioned Arup projects will be made clear, seeing the Personal Well-Tempered Environment as an example of Arup's approach of 'total design' - a multidisciplinary framework for building - and discussing how information itself can increasingly be thought of a material within building. With a holistic approach, it makes sense to consider information as part of the built fabric, just as with glass, steel, ETFE etc. The Well-Tempered ideas will begin to inform Arup's work on the ground, and vice versa, thus creating a constructive relationship between imagined informational architectures and pragmatic, deployed engineering.

Motivation for participating in the workshop

This workshop provides an opportunity to extend the thinking around our projects so far, testing the ideas against related work and discussing with others working in this field, subsequently wrapping the findings back into practical work through our projects and research at Arup.

Biographies

As part of the Foresight Innovation and Incubation team at Arup, **Dr. Duncan Wilson (duncan.wilson@arup.com)** is responsible for researching medium and long term futures with a focus on social and technology factors. He develops foresight and innovation capability within Arup, co-created the Drivers of Change concept, and programme manages a series of workshops on the future of the built environment. He was Principal Investigator on a Euro 1.4 million two year research project (DTI technology programme) applying wireless sensor networks in the built environment, is a partner in the European Union SENSEI project looking at networks of wireless sensor networks and is leading an internal research project on the implications of ubiquitous computing for Arup. His research merges interests in sensing and monitoring and creating interactive, ambient displays that solicit and feedback information with the intent of influencing behaviour. Duncan is a Chartered Engineer (IET), has a PhD from University College London in Artificial Intelligence and Machine Vision and blogs at http://www.driversofchange.com/emtech/
NB: The work at Arup is supported by two UK national programmes (DTI/TSB Technology Programme)

Dan Hill (cityofsound@gmail.com) has been working at the forefront of innovative information technology since the early '90s, and is responsible for many innovative, popular and critically acclaimed products and services He was Head of Interactive Technology & Design at the BBC in London for 5 years, before launching the critically-acclaimed international magazine *Monocle* during 2007, responsible for its digital services. He recently joined Arup as a Senior Consultant in their planning group, working with urban informatics. During 2007, Hill co-organised the *Postopolis!* architecture and urbanism exhibition/conference in New York City, and has a background in academic research and teaching in urban regeneration and urban informatics. His weblog *City of Sound* (http://www.cityofsound.com/) is generally considered to be amongst the foremost architecture and urbanism sites, recently voted by Planetizen as one of the ten best planning, design, and development sites for 2008 (http://www.planetizen.com/websites/2008).

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PROMOTING ENVIRONMENTALLY SUSTAINABLE BEHAVIORS USING SOCIAL MARKETING IN EMERGING PERSUASIVE TECHNOLOGIES

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Abstract
We argue that social marketing, a strategy that uses techniques from corporate marketing to influence the behavior of target audiences, is a useful framework for thinking about motivating people to enact environmentally sustainable behaviors. We critically examine some pervasive green applications through the lens of social marketing and discuss how we might study various persuasive factors encouraged by social marketers in these domains and in our own research.

1. Introduction

Social marketing uses tools from corporate marketing to influence the behavior of target audiences [1, 6]. Kotler and Zaltman, reflecting on successful marketing campaigns for products like soap, observed that some principles might translate to selling social causes. In the ensuing 35 years, social marketing has become particularly widely accepted in the public health domain, where it has been successfully used to influence behaviors concerning drunk driving and childhood obesity, for example. In this paper, we suggest using principles from social marketing to enhance persuasive technologies and help focus them on changing behaviors, and not just raising awareness.

2. Social Marketing: Setting the Stage

In his recent text [1], Andreasan describes a set of concepts, many from corporate marketing, that make the social marketing process effective. While social marketers emphasize the importance of considering the factors listed below, the degree of effectiveness of some of these factors has not been carefully studied. To that extent, one important research contribution will be the study of the effectiveness of these factors in the area of encouraging environmentally sustainable behaviors.

Benefits and Costs

Like obtaining a product, when an individual chooses to enact a certain behavior, they must pay some cost, and hopefully acquire some benefits. The social marketer's challenge is to sell the benefits while minimizing the costs. Related to this is how the benefits are presented. Research shows that the order in which requests of individuals are made can have a significant effect on engagement behavior [7]. In addition, the method of presentation can be very important [10].

Other People

Robert Cialdini has shown that 1) when deciding on a behavior to enact, people are strongly influenced by knowing what others are doing and 2) in certain situations, people report that they do not think they will be strongly influenced by others, but in fact these same people appear to be most strongly influenced by what others are doing [2]. This perhaps surprising result means that social influence can be particularly powerful because people do not guard themselves against such influence.

Self-Assurance (or Self-Efficacy)

Even if benefits, costs and other people are aligned in favor of an individual enacting a certain behavior, that individual may still not act. One reason is that they may believe they cannot enact the behavior. This is where we must provide support mechanisms like support groups (e.g. Alcoholics Anonymous) and skills training [13].

Segmentation and Identity

Because of large variability in target audiences, it is unlikely that treating the audience as one large, coherent market will be successful, and thus we should perform market segmentation. Identity-based marketing is related to this idea. Controlled studies have shown that if individuals with a relevant identity (say they are "green" individuals) that is primed (the individual is given content that surfaces "green" thoughts) are then much more likely to purchase a product related to that identity when compared to green individuals who were not primed [11].

3. Pervasive Green Applications through the Social Marketing Lens

3.1. Highly Sensed Virtual Environments

Green social networking site applications have been discussed in the literature [8] and appear online. One popular green application on Facebook is called "I Am Green" [4]. Users provide the application with a list of their green behaviors. Each green behaviors gets you a leaf, and you are compared to your other friends who have also installed the application. As a leaf collecting competition, it may be effective, but it is unclear if it is actually effective at advocating and motivating users to enact environmentally sustainable behaviors.

Consider the profile view of the "I Am Green" application in Figure 1. What is most prominent is the number of leaves the friends have, not the behaviors they enact. To leverage social influence, the application could instead say "4 of your friends recycle, even when it is not convenient." If four of my friends do it, based on Cialdini's work, we can hypothesize that we are already more likely to enact that behavior. Furthermore, I could click on the behavior and learn more about it, like its benefits and costs. Similarly, popular behaviors could be advertised.

Finally, recall the social marketer's emphasis on audience segmentation. Social networking sites provide such detailed information about individuals and their social network that creating audience segments of size one is possible. Indeed, we hypothesize that presenting users with recommended behaviors based on collaborative filtering instead of the most popular behaviors will lead to increased adoption of the recommended behaviors.

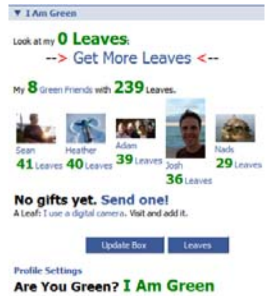

Figure 1: Screenshot from the I Am Green Facebook application

3.2. Dormitory Energy Competition at Oberlin College

On the Oberlin campus in 2005, an energy saving competition was run between dormitories [9]. The dormitories that saved the most energy, over a certain period, would win a prize. Building on the well documented effect of providing energy consumption feedback to reduce future consumption [3], the researchers provided one group of dormitories with real-time consumption information they could view on the Internet (see Figure 2 below for a particular residence, Kade Hall), or on an interactive display in the lobby of the building. Dorms engaged in the competition using these advanced monitoring systems saw significant energy reduction, over and above those dorms that did not have such detailed monitoring technology. However, examination of energy consumption patterns after the end of the competition suggests that the numbers have returned to near their original, pre-competition baseline [5]. From a social marketing perspective, this is not surprising. One of the primary benefits offered to students in the dorms was the potential to win the competition. When the competition is discontinued, both the benefit of having a prize, and the benefit of friendly competition, disappear, and what's left is the somewhat intangible benefit of reducing the campus' electricity consumption and maybe indirectly helping the planet. This is one hypothesis for the return to the baseline. We could examine the benefits hypothesis in future competition by redesigning the benefits to be seen as continually useful. Another possibility is to ensure the benefits remain for a long enough period so that individuals internalize their behaviors. Such work has been done in residential settings.

4. Our Work

We intend to study the effectiveness at reducing consumption of the social marketing concepts outlined above, and game-like mechanisms (e.g. competition, scoring points) as demonstrated in the Dorm Energy Competition. First, we can perform basic experiments in a laboratory setting to study the impact of different social marketing factors incorporated in technologies on behavioral change (as in [2, 7, 10]). In the field, we hope to study these factors in two domains:

4.1 **Highly Sensed Virtual Environments**

In an online social networking environment, we will build an application that promotes environmentally sustainable behaviors. The application may be similar to the "I Am Green" application, in that users must select behaviors that they enact. Concretely, we would then manipulate the persuasive factors mentioned above for different groups, and monitor the uptake of behaviors. Here are some of the persuasive factors we may study:

Social Influence: since the application sits on top of a social network, we can leverage information about friends. We can present performance information about friends, make comparisons between individuals and their friends

Game Mechanisms (scoring, competition): behavior choices might be translated to a score (like leaves in "I Am Green") and can be billed as a competition amongst participating individuals

4.2 Reducing Individual Energy Consumption in Office Spaces

Office buildings consume a huge proportion of energy in most countries. Lighting and electronics usage by individuals is a significant component of office building energy consumption. We are building a dashboard display for an office space. Based on survey work by the Center for the Built Environment at Berkeley, often office occupants feel they have very little control over energy consumption in their space. Thus, one experiment we may run is between visual displays that only display consumption information, and those that display consumption information and promote appropriate behaviors for changing consumption in the space.

Game mechanisms may also be effective in this domain. A study [12] showed that competition between office spaces yielded increased reductions when compared to spaces that did not compete.

5. About the Authors

Omar Khan is a 3rd year PhD student studying human computer interaction. He is trying to persuade individuals to enact environmentally sustainable behaviors. John Canny is the Paul and Stacy Jacobs Distinguished Professor in the UC Berkeley Department of Computer Science. His research interests include activity-oriented design and educational and persuasive information systems.

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CONTEXT-AWARE PERVASIVE PERSUASIVE SYSTEMS FOR MANAGING WATER AND ENERGY USAGE, AND CO2 EMISSIONS: MULTI-LEVELLED POLICIES, GOALS, AND AN EXPERT SYSTEMS SHELL APPROACH

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Abstract

We propose a technological solution to the general problem of empowering individuals to take actions related to environment sustainability, going beyond mere reminder systems or simply passive written guidelines. Resource-usage policies at the home, community, state or national level will be encoded in a formal rule-based language and so, translatable to policies or goals at lower levels of granularity.

1. Introduction

This position paper outlines a technological solution to the general problem of empowering users to take actions related to environment sustainability, going beyond mere reminder systems or simply passive guidelines. Our position is that such a system can make a difference. Several systems have been proposed in the water and energy domain [1,2,5], in order to encourage prudent use of resources based on the idea of persuasive technology [3]. More generally, the idea is to develop systems which can autonomously

(i) quantify effects of actions and measure consequences (whenever measurable) – e.g., actions related to usage of resources such as water and energy, and CO2 emissions; such quantification can be in terms of low-level activities: for example, what is the cost of this handwash? How much of CO2 emissions will leaving this device running till I return from dinner cost me? etc

(ii) help users be aware of such effects and consequences, and then

(iii) facilitate users adjusting their behaviour or attitude with respect to goals related to these effects and consequences.

The goals related to resource usage or CO2 emissions may be specified as policies at different levels, by users themselves, by the local council, the state government or even a national body. User goals might be shaped by policies from above. A system which can automatically map a high level national goal to goals tailored for individuals would help individuals make a difference.

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2. Architecture

Buildings blocks of technology is available for a system automating this process of taking high level goals and helping users "digest" and be influenced by these goals in daily life. We outline the key aspects and associated technologies of such a system, as follows:

- **Fine-grained metering and monitoring**: ideally, devices should be available to capture usage of resources at different outlets (e.g., for water, be able to monitor usage at different sinks or faucets) as well as usage of the entire home or floor or building, and perhaps, with some instrumentation, resource usage of particular individuals in the home.

  The problem of labeling *an instance of resource consumption* (which we define as any distinguishable action or activity employing a countable measure of resources, often, but not necessarily, having an identifiable start and end time, e.g., opening a kitchen water faucet for a certain period, or switching on a lamp for certain time) with its particular time, place, actor (the user of the resource), and purpose is generally difficult though not impossible with adequate instrumentation for the user. Traditional metering is, hence, merely confined to units of resources used but more information about how and why resources are used will help computer automation of resource-control, as we discuss further below.

- **Data processing and situation understanding**: once resource usage can be tracked, one would need to process the data from such metering, either to translate processed data into appropriate visualization forms and various status displays to simply inform users, or more elaborately, to trigger particular persuasion strategies to influence users' (or consumers') behaviours and attitudes towards goals (which may encompass status displays, but more than that, also other persuasive messages or actions to take (e.g., reducing water flow in a long shower) according to persuasive techniques being employed), as we consider further below.

  The system could also perform longer term analysis of metered data to determine usage trends over days, weeks, months or even years. Understanding situations of use of particular units of resources can help inform the system about what actions to take or messages to use at that instant. There has been tremendous amount of work in sensor-based inference of users' context and situations [4], as well as inferring user's current activities.[4] Useful context here (with regards to water, say) include the identity of individuals, the location where water is being used, the time in which water is being used, the activity for which the water is being used and the urgency of the use, current water costs, user-specified cost/water usage goals, current water levels and current policies on water restrictions, all of which aggregates into situations of use, which can then be mapped to appropriate persuasive strategies and messages.

  For a given type of resource, models of what constitutes normal resource usage, wasteful usage, and conservative usage will be needed. Further finer demarcations than these three might be useful, or fuzzy categories.

- **Action strategizing**: Given an instance of resource consumption, a system will have rules which could map the collection of (i) metered data, (ii) usage trend knowledge, (iii)

[4] http://www.activity-based-computing.org/

computed effects of the resource consumed, (iv) policies (at home, community, state or national level) and associated goals, and (v) the inferred situations of use, to actions to regulate usage in that instance (possibly even identifying wastage or non-usage).

Actions can range from simply notifying users, i.e. displaying to users cost or water levels in a visual form, advice on water-saving for specific tasks, various forms of reinforcement messages, just-in-time prompts, social validation (e.g., where possible show the best water users in the home), adaptations (according to usage history or current needs), negotiation (e.g., to keep to a previously specified budget, the user can use more water this time but have less to use next time), recommendations of water saving devices, to taking action on behalf of the user (e.g., stopping water flow at certain times – if the user so authorises such pre-settings).

- **Feedback and strategy revision**: there is a cycle of monitoring resource usage and situations of use, adopting a course of action and a corresponding persuasion strategy, following the strategy, and then adjusting or revising strategies midway depending on detected changes in resource usage (e.g., due to users' behavioural change). Such a cycle of processing is akin to the paradigm of knowledge-based intelligent agents [6], which runs in the "background", as depicted in Figure 1.

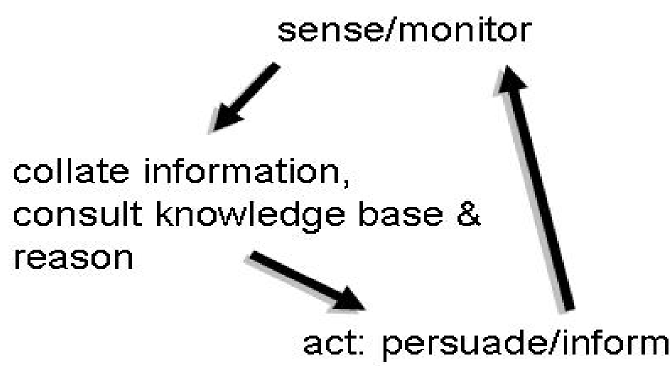

Figure 1: Overall system behaviour – a cycle of sensing/monitoring resource usage, reasoning about the way the resource is used and acting

3. Conclusion

The above system is under development and we plan to build a shell in the expert systems style which can be instantiated with different models of resource usage behaviour, persuasion strategies, action modules, and knowledge about what actions to take in different situations, to help manage the usage of a particular type of resource. Such a system can be interfaced to various resource monitoring devices and displays for persuasive messages.

Resource-usage policies at the home, community, state or national level will be encoded in a formal rule-based language and so, translatable to policies or goals at lower levels. For example, a goal for water usage at the home level can be created based on a community policy. The system will then, while monitoring resource usage or computing its effects (e.g., greenhouse gas emissions), adopt various persuasion strategies and interact with the user to help meet this goal.

Thereafter, experiments with the system and usability evaluation in real settings will be done with users. There are issues related to producing and employing the necessary monitoring equipment for the systems we propose here, since that itself could lead to further energy consumption (which remains to be measured), and raise concerns about privacy. It is possible to only use monitored information for the purposes of providing advice to the user or prudent messages, but this implies careful safeguarding of gathered context information (indeed mechanisms to allow users themselves to regulate context information or protect privacy has been considered elsewhere, e.g., [7,8]) – not insurmountable but possible with existing policy-based solutions. In addition, while CO_2 emissions might not be decisively quantified at this time, relative measures might be applicable and usable in our approach. Lastly, our solution relies on prudent persuasion rather than coercion, and so, it is possible for individuals to ignore the messages of our system – the role of our system is, hence, to empower, encourage, and facilitate those already desiring to make some difference. While this paper has proposed a technological solution, further social and cultural implications of our proposal remains to be explored.

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Biography

Dr. Seng Loke is a Senior Lecturer at the Department of Computer Science and Computer Engineering, La Trobe University, Melbourne, Australia. He has authored and co-authored more than 170 research publications, and leads the Pervasive Computing Group at La Trobe. Prof. J. Singh is Director of the Center for Technology Infusion, at La Trobe University, Melbourne, Australia, and Research Professor. Dr. Hai Le is Research Fellow at the Center for Technology Infusion, at La Trobe University. The team, recently formed, works on cost-effective computing and engineering solutions to the important issues of environmental sustainability.

The workshop will be highly useful as a forum for interacting with experts in other fields, and in creating a multidisciplinary understanding of the issues (and perhaps solutions) at hand.

Using persuasive technology to encourage sustainable behavior

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Abstract
In this paper sustainable consumption is conceptualized as the result of various types of interactions between users and systems. We review attempts to promote sustainable behavior and discuss contributions by using persuasive technology. In particular, we focus on the appraisal of climate risks and interactive approaches to influence energy consumption in households.

1. Introduction

The impact of human activity on the natural environment has severely affected the ecosystems on earth and in the long run might lead to serious threats to human life and civilization. The environmental impact of humans can be roughly assessed as a function of their numbers, their affluence, and the technology they currently use (cf. Ehrlich & Ehrlich, 1991). However, despite the fact that humans have used technology as long as they have consumed natural resources, technology as related to environmental resource use, is often set apart from the study of human behavior and resource conservation. This separation has hampered interventions to protect natural resources and constrain negative environmental impacts.

Various studies have shown that a purely technological approach to reduce energy consumption often leads to disappointing results due to changes in user behaviour, which have been described as rebound effects (Midden, Kaiser, McCalley, 2007). Also, resistance to new systems and negative experiences, for example due to faulty automation or lacking user friendliness, has frustrated the high hopes of innovative technologies. On the other hand, the effects of purely behavioral approaches have been very successful neither or mixed at best (e.g. Weenig & Midden, 1997). One of the main reasons for the lack of success is that most communication programs targeted the intentions of users, but largely ignored the technical context in which consumption choices actually occur. Basically, we view energy efficiency and conservation as the outcomes of multiple interactions between technological systems and human users. It follows that interventions that aim to influence consumption behaviour should be concentrating on guiding interactions between users and systems.

The linkage between technology and sustainable user behavior can be described by distinguishing four roles of technology: (1) as an *intermediary*, where the technology used for attaining a goal defines the ecological impact, although often surrounded by uncertainty; (2) as an *amplifier*, where technology amplifies the human potential to attain goals, but at the same time it amplifies the use of resources (3) as a *determinant,* where behavior is shaped and activated on the basis of the affordances, constraints and cues provided by the technological environment and (4) as a *promoter*, where technology is designed to influence behavioral choices (Midden, Kaiser & McCalley, 2007).

Although it would be worthwhile to consider each of these roles as a perspective to design persuasive interventions that enhance sustainable consumption, we will focus in this contribution on the fourth role of technology, that is the role of promoter.

2. Technology as promoter of sustainable behavior

How can people be motivated to use scarce natural resources in a sustainable way? In the search for effective interventions we ask how persuasive technology can help to overcome some traditional limitations and make motivational strategies more powerful. We discuss this role of technology regarding two foremost challenges that policy-makers and psychologists face in combating the major environmental risks of CO_2-emissions and climate change. First the use of media technologies is explored, to see how they can help enhance problem awareness. Second, we focus on interventions to change behavior and the ways technology can be used to make interventions more effective.

2.1. Using novel media to raise risk awareness

Since the 1970s, worldwide numerous mass-media campaigns have been used to raise concern for the threats to natural eco-systems and the urgency of action. Results have often been disappointing. Among the many issues that have been identified, attention and processing issues form an important part.

Looking at attention rates, many mass-media appear not to be used by the general public. Traditional visual media such as television ads and video-clips have also been used to stimulate environmental awareness and conservation behavior. However, visual media are not more motivating per se for enhancing sustainable *behavior*, in spite of their easy access and less demanding processing (Weenig & Midden, 1997).

More advanced multimedia technologies may add persuasive impact to the traditional communication of transferring symbolic information (like text or speech) by inducing direct sensory experiences like sounds, images, scent and touch that create ’presence’, the feeling of ’being there' in a mediated environment (see for an overview IJsselsteijn, 2004). It may allow people to better conceptualize cause-effect relationships, such as how an urban area would look and feel like without car traffic or how the world would be after serious climate change. More recently, significant research efforts have been directed toward investigating the relation between ’presence’ and emotional impact (measured through, e.g., galvanic skin response or heart rate variability), where findings are supportive of the existence of such a relation, in particular in relation to fear-inducing media environments (Meehan, Razzaque, Whitton, & Brooks, 2003). Research in the domain of environmental risks has convincingly demonstrated the role of affect and emotion in risk perception (e.g., Slovic, Finucane, Peters, & McGregor, 2004,). Some experimental evidence is available which shows that video images with emotionally charged content stimulate attention for climate risks and coping options. The use of intrusive images and dramatic sounds to alert people were found to enhance relevant information processing for coping with these risks (Meijnders, Midden & Wilke, 2001).

These studies suggest a new area of inquiry in which virtual environments can be used to offer new opportunities for technology assessment by giving people pre-experiences of future technology effects or newly planned environments and facilities, which will go beyond verbal descriptions or abstract representations. Ongoing work in the Netherlands focuses on the cognitive and motivational effects on coping behavior as a result of user experiences in a virtual polder environment, which is threatened by dike collapse (Zaalberg & Midden, in preparation).

In sum, traditional media have had limited success in promoting environmental problem awareness, but new multimedia technologies show more promise in this endeavor by offering new opportunities for creating and enriching sensory experiences as a route to raising awareness of future and/or distant issues, to explore cause-effect relationships and to experience environments that are not directly observable. However, despite the possibilities offered by multi-media technology, raising awareness will not be enough to fight climate risks and diminish the use of natural resources. In the next section we turn to the role of technology in accomplishing behavioral change.

2.2. Using Persuasive Technology to Promote Energy Conservation Behavior

Prior to the 1990's, experiments using electronic devices indicated that they might contribute to the efficiency and effectiveness of behavioral interventions, but technology just wasn't yet smart enough in most cases to make these devices very successful. Psychologists have as yet merely touched upon the opportunities offered by intelligent systems to promote (energy) conservation behavior. Most early work was done on the effects of feedback on energy consumption in the home. Studies often used simple procedures like written messages based on daily or weekly meter readings, while some researchers used electronic displays. Electronic modes of feedback have been proposed to solve a number of issues related to written modes. First, electronic means could provide feedback more quickly and frequently than written feedback, even continuously, thus making the consequences of specific behaviors better available for the consumer. Second, electronic feedback could be given at more central locations like the living room or the kitchen. Third, electronic feedback allows for the use of multiple standards (e.g., personal and social), reference points (e.g., financial costs per hour, the previous day or the upcoming month) and units (e.g., $ or emitted CO_2). Fourth, written feedback provided with a high frequency has been quite effortful and costly. Automation could make the feedback process more efficient. Fifth, instead of the usual aggregated feedback at the household level, electronic feedback could be source-specific (e.g., the airco or the cooker), evidently creating a closer link between feedback and action (e.g. Wood & Newborough, 2003).

In sum, electronic means have made it easy to provide highly frequent feedback, which is more effective. Electronic devices have also facilitated feedback on specific appliances, which appeared to be more effective than general feedback. Goal-setting, added to electronic feedback, enhanced energy savings.

Almost all interventions were designed to communicate with subjects in a one-way direction. Modern intelligent systems enable two-way interaction between user and system, which allows for more precise targeting of tasks and for personalization. To illustrate, interactive systems allow for the implementation of more refined goal-setting procedures and the provision of more specific information, not only to specific appliances but to specific tasks as well. Interactive devices are still rare in the domain of (energy) conservation behavior. Some studies, however, illustrate the potential. The present authors observed in two earlier studies (e.g. McCalley, 2006) energy conservation results up to 20% using washing machines with a user interface that allowed for interactive goal-setting and outcome feedback. During a series of twenty washing tasks, users received immediate feedback each time they made a choice for a washing program to carry out a particular task. Subjects with either self-set or assigned goals saved more energy than subjects without an explicit goal.

Applying intelligent agent technology that learns from the users and interactively communicates on a personal basis could enhance the power of supportive systems. We use the term agent to refer to a piece of software that can be considered as an autonomous creature able to perform tasks with more or less intelligence and autonomy. It can be made visible in many ways through virtual or physical forms of embodiment (e.g. Diesbach & Midgley, 2007). An agent system could be able to frame outcomes based on the current context or user, or to encourage the user to make certain goals more explicit, and even make suggestions on how to act or guide a user to a decision. In this role, intelligent agents may become persuasive social actors, rather than simple tools (e.g. Fogg, 2003). In a very recent study (Midden & Ham, 2008) demonstrated that social feedback from a physically embodied agent, an iCat (Philips company), resulted in significantly more energy conservation behavior on the same washing tasks than the factual feedback like provided in McCalley and Midden study.

3. Conclusion

In this paper we discussed behavioral interventions on enhancing sustainability with a focus on human-technology interactions. Four roles of technology have been suggested and the role of promoter of sustainable behavior has been explored in greater detail. Our review reveals that persuasive technology has much to contribute to the design of effective motivational interventions. It helps to raise awareness of future or distant issues, such as the vast melting of polar ice, or to lower thresholds for change, for example by making it possible to experience a building not yet constructed or to explore cause-and-effect relationships such as the effects of ventilation on air circulation in the home. Technological assistance may go beyond the level of specific appliances or systems and direct energy use. For example, the application of computer and robot technologies to domestic appliances) will be able to monitor multiple sources of energy use and support home energy management. Such systems will offer advice on saving options taking account of personal lifestyles and will even be able to support strategic decisions like investments in equipment and home renovation. Sustainability requires joint efforts in various social groupings (e.g. household, neighborhood). Persuasive systems may also be able to touch this social dimension of sustainable behavior for example by coordinating contributions.

Interventions that aspire to integrate psychological with technological means form a challenging perspective. We believe, however, this effort to be most worthwhile on the route to a society that makes sustainable use of its natural resources.

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Participate: Producing A Mass Scale Environmental Campaign for Pervasive Technology

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The Participate[2] project is exploring how pervasive computing can support future mass scale environmental campaigns in which the public upload and access information about their local environments and engage in reflection, discussion and debate. We introduce the idea of 'three layer participation' in which members of the public collaborate with broadcasters, networks of schools and other organisations as part of a multi-faceted campaign. In the first phase of the project, we have conducted three exploratory trials focusing on schools, visitors to Kew Gardens in London, and members of the public playing a pervasive game on mobile phones. Based on our experiences in these trials we outline the research challenges to be addressed in the second part of the project and that define an agenda for supporting future participatory campaigns.

1. Introduction

At the turn of the 21st century we have become engaged in a global debate concerning the nature and impact of climate change and our role as individuals, societies and indeed a global community in managing our environment. In order to pursue this debate we must address three key challenges. We need to *gather information* about the environment on a greater scale than ever before, we need to *inform the debate* by conveying environmental knowledge in new ways, and ultimately, we will also need to *persuade people* to change their behaviours.

We believe that pervasive computing can ultimately engage millions of people in mass participation environmental campaigns, raising awareness of environmental issues, supporting education, activism and democracy, and delivering environmental data on a scale never before possible.

[1] and Amanda Oldroyd (BT), Andy Gower (BT), Adrian Woolard (BBC), Nick Tandavanitj (Blast Theory), Steve Benford (University of Nottingham), Danae Stanton Fraser (University of Bath), David Crellin (Sciencescope), Richard Harper (Microsoft Research Cambridge)

[2] See www.participate-online.org for information about the project including recent papers

2. The Participate Project

Participate is a UK project to explore the potential of pervasive computing to support mass participation environmental campaigns. The project brings together a consortium of industry and academic partners to collectively explore how the convergence of mobile, online and broadcast media can enable a broad cross-section of the public to contribute to, as well as access, environmental information – on the move, in public places, at school and at home. The partners and their respective interests are: BT (telecommunications), The BBC (broadcasting), Microsoft Research (computing), ScienceScope (sensors and dataloggers), Blast Theory (artists), The Mixed Reality Laboratory at the University of Nottingham (pervasive computing) and the School of Psychology at the University of Bath (learning technologies).

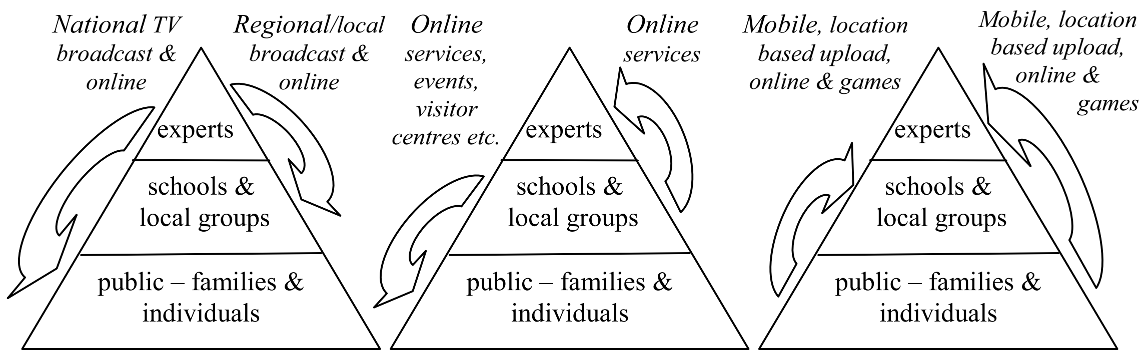

Figure 1: Three layers of Participation

Inspired by a history of television led 'big science' projects in the UK, such as the BBC's annual Springwatch campaign [1], Participate is exploring a generalised 'three layer' approach to participation as shown in figure 1.

- **The public** – individuals and families – establish a general background picture of 'quality of life' factors across the country.

- **Schools and local-groups** carry out focused investigations of particular localities, drilling down into the background data in more detail using more specialised sensors and dataloggers.

- **Experts** working with broadcasters drive and shape the overall campaign, assimilating information and feeding it back.

Participate began in January 2006, and at the time of writing (January 2008) has just reached the beginning of its final year. The initial eighteen months of the project involved designing, deploying and studying three focused trial experiences to test initial ideas and technologies; the schools trial, the community trial and the public trial. The schools trial brought together different schools in a series of multi-study technology-supported science activities. The community trial involved visitors to Kew Gardens engaging with interactive posters and large displays and making and sharing their own video documentaries. The public trial involved creating a context-aware game for mobile phones called *Prof.*

Tanda's Guess A Ware that attempted to build a picture of the player's environmental behaviour over a period of several weeks, inviting them to reflect on or even change their daily routines. The trials explored different contexts and approaches to participation across our different layers, and their results are now being fed into the design and development of a final integrated large-scale public campaign that will take place across the UK in the Summer of 2008.

3. A Research Agenda for Mass Participation Campaigns

Our initial experiences in the schools, community and public trials have informed an emerging research agenda for the second half of Participate and we hope for future research into mass participation campaigns in general. This agenda includes the following research issues.

Reflection, feedback and personalisation: The next major challenge is to encourage participants to reflect on the data gathered and on their own environmental behaviour. How can environmental information best be summarised and presented back to participants in different contexts? How can participants understand their own information within an aggregated whole? How can we portray historical information? And what are the roles of broadcast and online channels in this?

The role of pervasive play in persuasion: Do such games such as 'Prof Tanda' have a special role to play in actively shaping behaviour? Can they engage new audiences who may not respond to traditional challenges? How and when can we best interrupt people? What level of contextual knowledge is required if such games are to be effective?

Digital rights and digital footprints: Our experience in the schools trial shows that the reuse and publication of gathered information can be a complex and tricky issue, especially with regards to the recorded movements of children. How do rights issues affect people's motivation to participate? Is there an appropriate framework for negotiating the reuse of information, both in original and aggregated forms, that can be understood by individuals and yet is flexible enough to serve the needs of multiple regulatory needs, including those of schools and broadcasters? What are appropriate technical points of control within a system, specifically are peer-to-peer or centralised approaches more appropriate?

Human-sensor dialogue: The nature of interaction between humans and sensing systems is an ongoing topic of research within HCI (for example [2]). Participate raises new questions here, especially concerning the integration of mobile and fixed sensors. Building on the schools trial, how can we extend mobile sensors to compare individuals' experiences of and interactions with an environment? Conversely, how can sensors that are fixed in the environment engage passers by, providing them with location specific information or encourage them to annotate sensors readings with qualitative information such as images of the local context?

Technologies, channels, preferences and modes of participation: Given that there are various technological means of participating in an environmental campaign, what is the relationship between technology type and participant type?

4. Conclusion

In conclusion, we believe that pervasive computing has a key role to play in helping inform environmental debate and supporting people in reflecting on and even changing their behaviours. Participate has brought together a unique consortium of industrial and academic partners to explore this topic, developing new approaches and technologies and also defining the research agenda for future mass scale environmental campaigns. This paper has articulated some key research challenges that have emerged from our initial forays into this territory. The second phase of the project will involve exploring these within the context of a final integrated large-scale trial.

5. Acknowledgements

We gratefully acknowledge the support of the UK's Engineering and Physical Sciences Research Council (EPSRC) and Technology Strategy Board for funding this work. We would also like to thank the many researchers who have contributed to Participate and also our external partners Kew Gardens and all the schools, teachers and pupils who have taken part in this research.

6. About the Authors

Mark Paxton is a researcher and PhD student at the Mixed Reality Lab at the University of Nottingham. His background is in Electronic and Computer Engineering, and research interests explore human-sensor dialogue. His involvement with the Participate project relates primarily around the use of environmental sensors and datalogging equipment in educational contexts, and his previous work has investigated educational use of mobile phones in schools and e-science techniques for the study of the environment in schools.

7. Workshop Aims

We would like to share our experiences from the three trials in the initial stage of Participate with fellow researchers in environmentally engaged areas of pervasive and persuasive computing, participatory sensing and HCI. We would welcome the opportunity discuss the Participate project and our ongoing work with other workshop participants. We would also like to pursue opportunities to expose the platforms and methods we have developed to a wider audience with a view to possible future collaborations.

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THE DESIGN OF *IMPRINT*: “WALK THE WALK” AND OTHER LESSONS

Zachary Pousman, Hafez Rouzati, Katie Collins, John Stasko

Biography

Zachary Pousman is a PhD student in Human-Centered Computing at Georgia Tech. He works in the Information Interfaces lab, headed by John Stasko. Zach's research centers around casual information visualization, infovis systems for everyday people dealing with the volumes of information that they generate and encounter. Zach has a Masters of Science in HCI from Georgia Tech and a B.A. in Philosophy from the University of Chicago.

Abstract

We introduce Imprint*, a casual information visualization system that showcases data extracted from a printer queue. The system filters and aggregates data including layout information, text, and images, and displays interactive visualizations on a large touch-screen display mounted above the physical printers that serve a small community.* Imprint*'s visualizations depict environmental issues, such as energy consumption and paper consumption of the printers, as well as social information, such as popular concepts from the printed matter. Imprint is intended to spark reflection and conversation, and to bring data into discussions about paper usage, "waste," and extrapolation. The goal is not to explicitly reduce paper, energy, or toner usage, but instead to open some of the very questions that might, for example, cleanly delineate what counts as waste when it comes to the printers as they are being used by the community. We note an emerging list of design strategies that have helped us to explore these issues. The first we term "eating the dog food," or walking the walk—when a visualization brings up environmental impact data it must also disclose how much environmental impact the system itself produces as it operates. Others may follow, including the use of defamiliarization, and the use of social particulars in visualizations.*

1. Introduction

The modern world is full of traces, ways in which human activity, either individual or aggregate, leaves behind some residue or trace. These traces are often invisible, untracked and unexamined. But like Bowker [2], Star [9], and others who research how infrastructure is understood and made visible, we seek to make these often invisible traces visible for the community. In doing so, we hope to draw a community's attention to the ways that infrastructure shapes its understanding of the world and of itself, and to draw the community into reflection, contemplation, and conversation.

Imprint is a system that monitors a printer or group of printers and creates simple interactive visualizations of the datastream that passes to the printer(s). *Imprint* shows casual information visualizations [7] on a large touch screen above the printers that it monitors. *Imprint* visualizations depict either social information, information about which members of the community are printing, and what concepts are popular, in addition to environmental information, information about how much paper, toner, and energy are being used as individuals print their documents.

Our design goals with the system are twofold. First, we seek to create a conversation piece and to foster novel reflections on the datastream of printer traffic. We are not attempting to modify the behavior of members of the community; we do not want to build a system that bullies, badgers, cajoles or shames community members into changing their behaviors (i.e., into printing fewer pages). This kind of intervention, even if it were achievable, might not cause long-lasting behavior change, but instead might cause users to "route around" the *Imprint* monitoring system by, for example, printing more at home. This is exactly why we designed imprint to be intentionally vague in its presentations (see figures below). Our second design goal is make Imprint provocative enough to elicit suggestions and comments from community members for new visual depictions and visualizations. Our hope is to design the system to be a framework through which community members can ask new and better questions about this data set.

2. Related Work

We take inspiration from Gaver *et al*.'s Home Health Horoscope [4] and the general approach to designing for ludic engagement. Ludic engagement is a design strategy for engaging the playful parts of human life, as opposed to targeting the task-centric and analytically solvable parts of human life (which is the implicit focus of much technological intervention) [3]. From here we take inspiration not to "solve" wasted printer pages, and instead to engage a workgroup or community in playful reflection.

We note prior examples of systems that display environmental impacts and traces to occupants of work spaces. Holmes' *7000 oaks and counting* is an ambient display and casual infovis system that reads building automation data to determine a real time carbon footprint of a building [5]. Jeremijenko's *Stump* creates visual tree rings as coversheets instead of the usual coversheet metadata [6]. The coversheets could be stacked to form a stump made from wasted paper.

3. System Architecture and Interaction

3.1 System Details

Imprint is built of three main components: a modified print server, a data store, and the visualization front end. *Imprint*'s backend is built on a Mac OS X server, which runs the Common Unix Printing System (CUPS), which has a modified backend to retain print job files. Imprint processes print job files and passes them to an Apple Core Data store. The Core Data store serves raw visualization data to a second computer which builds and displays the visualizations. Touch screen input is provided by a Smart Technologies overlay. We log interaction data from *Imprint* in a SQLite database.

3.2 User Interactions

We are still constructing the interactive capabilities of *Imprint*. Imprint displays simple visualizations in a slideshow presentation, each slide appearing for a period of 30 seconds, before moving to the next slide. In this way, we can show multiple perspectives on the printer data, with individual visualizations focusing on individual aspects of the data. Users may select large next and back buttons to move to different slides.

Users may also filter and query the dataset in each slide by activating a dynamic query slider. Dynamic query sliders allow users to create complicated queries of a dataset with ease, since they are an extension of the normal scroller/slider control found in many applications and systems [8]. The dynamic query slider allows users to modify the date range of the visualization.

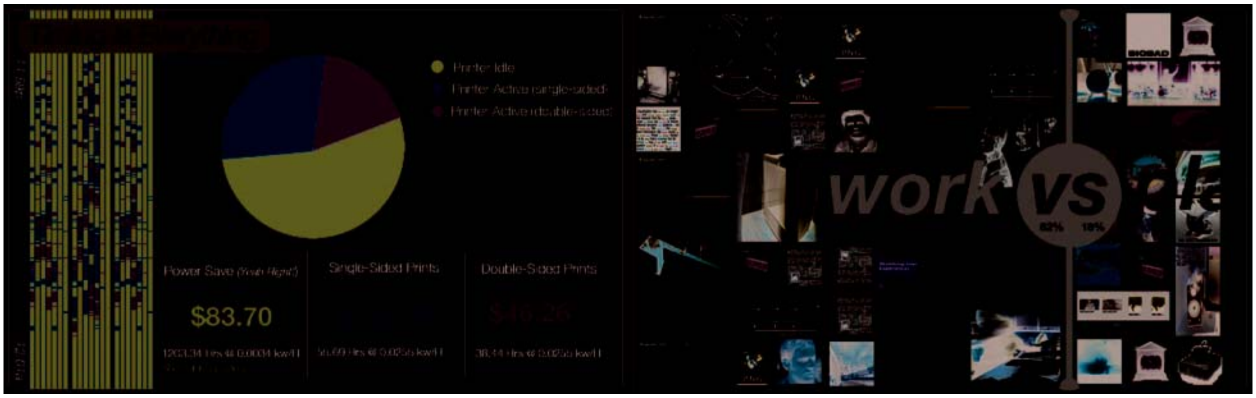

Figure 1a: The *Timing is Everything* display. Stripmap on the left shows 3 weeks of data of printer activity (idle, one-sided documents, two-sided documents). The bar graph in the center shows aggregate data, with prices. **Figure 1b**. The *Work versus Play* display. An aggregate count of documents that included the word *"work"* are compared with those that include the word *"play."* This ratio is represented by the gray *vs* bar. Random sub-images from images in work and play documents appear in their respective areas.

4. Design Strategies

4.1 Walking the Walk

Imprint brings up environmental concerns by creating visualizations of energy consumption, paper usage, and toner usage. As such, *Imprint* must be sensitive to these concerns and issues. And it should do so in a public manner, where users (and even passers by) can see how seriously the designers have internalized these concerns. *Imprint* includes a slide view that states how much energy the system itself has required to run. It totals the sum of the energy to power the display, the display computer, and the server. We also calculate the dollar value of this electricity and display that as well. In this way, we are not just talking the talk of environmental impact (and the traces left by our actions), but also walking the walk.

Walking the walk confers three main benefits: it lends credibility to the system and to the designers, it preempts potential questions, and it may be a spark for further reflection. Walking the walk lends credibility to the system because it looks at the same issue (energy consumption) from another perspective inside the same system. Putting our energy consumption out for all to see conveys that we are not embarrassed by it (it is just data), and that, in some sense we are not judging others (or at the very least not judging others more than we judge ourselves). Walking the walk can preempt user questions about the work, since it serves a function of being part of the "full disclosure" of the system. Lastly, the visualization of our own energy consumption can serve as a spark for reflection by users, especially since it can be compared to the core datastream. Users can use the amount of energy used by the system to compare against the total amount of energy used to power the printers themselves.

4.2 Defamiliarization

We are exploring with our visualizations some of the notions of defamiliarization [1]. Defamiliarization is a design strategy that appears in much of art, where the normal way of seeing or understanding some topic can be challenged by showing the object or topic from a novel perspective. Removing the printers from their normal everyday role and making the words printed each day the focus of visualizations helps to remove them from the everyday experience (printing, reading) and to find new ways in which they make sense (as art objects, as part of a community of concepts).

4.3 Sensitivity to social particulars

Imprint is designed, in its current iteration, for a particular kind of community, and in fact a particular community. It is heavily customized for our own HCI community at Georgia Tech. Visualizations of academic communities have particular attributes that we seek to highlight with our visualizations. One salient one is that members often print the names of other members in the community (in references sections and elsewhere). Another particular we emphasize with our visualizations are implicit or explicit tensions that may be at play in the community. Some researchers at Georgia Tech are more interested in work tasks while others concern themselves with play (there is even a lab group called "Work2Play"). These identities and opposition words also become visible in the visualizations.

5. Concluding Thoughts

We are really just beginning to explore deeply both the topic of environmentalism and the attendant ways that system design must change to accommodate this domain. Our first stake in the ground has been to "walk the walk" by creating a simple visualization that publicly announces the amount of energy used by our system. Our current work is a deployment on our own floor, a floor of an academic research building at Georgia Institute of Technology. Our plan is to measure the effects of the intervention, both in qualitative and quantitative ways, using a mixed methods approach. Our aim is to determine the degree to which members of our workgroup interact with the system, use it as fodder for conversation, and, perhaps, modify their behaviors. By the time of the conference, we may be able to report on preliminary results.

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Understanding and influencing spatio-temporal visitor movement in national parks based on static and dynamic sensor data

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Within large urban agglomerations national parks play an important role in the daily life of the citizens: apart from influencing the local climate they are major areas for recreation. National park operators strive to balance the needs of individual visitors with the needs of wildlife and plants and find a way to motivate people to respect restricted areas. A current project in Vienna aims at influencing the movement patterns of visitors by offering user centered information that takes into account the spatiotemporal behavior of the other visitors and the national parks infrastructure information. The spatiotemporal behavior is collected via a variety of sensors including GPS enabled PDAs, which also function as guiding devices.

1. Management of National parks: balancing recreation vs. protection needs

Within large urban agglomerations parks play an important role in the daily life of the citizens: apart from influencing the local climate they are major areas for recreation.
There are a quite a large number of cities where national parks or biosphere parks are part of a city or close to its borders, e.g. Vienna, Austria, Sydney Australia or the 2014 Olympic host city Sochi, Russia.
The wider Viennese urban area has about 2.5 million inhabitants and two national parks in the vicinity. Sydney has about 4.1 million inhabitants, who can reach more than five national parks for a day trip. The Sochi National park is located in the mountains that surround a city of 390.000 inhabitants. In conjunction with the upcoming Olympic Games and the impact of the expected increase in tourism it is currently discussed how the national park can be protected.

One of the major questions the national parks face is: how to protect the nature, while at the same time offering access for as many people as possible?
For the operators of national parks it is of utmost importance to balance the needs of individual visitors with the needs of wildlife and plants and find a way to motivate people to respect restricted areas. Therefore national parks and their visitors need information about each other in order to offer, plan and enjoy visits, while at the same time protecting the nature.

Based on these needs a research project in Vienna currently examines the movement patterns of national park visitors with a variety of sensors and methods. The idea behind the project is to get an overall picture of the visitor movement (based on historic and real time data), associate the movement data with infrastructure information of the park has (e.g. sensible spots, spots to see special flowers and plants, etc) and influence visitor movement with regard to nature protection issues. To influence the visitors they will receive two different sets of information when entering the park: either a more general information on where to go and what to visit – based on historic data – or real time information tailored to their interest via a GPS enabled PDA. The ultimate goal is to significantly influence the distribution of visitors within the national park, thus distributing the stress for the nature more evenly, while at the same time protecting special areas.

2. Collecting, predicting and influencing spatio-temporal movement

Three different research institutes cooperate with two national parks to make sure that the developed technology fits the user needs of the park operators and the park visitors alike. The research teams focus on the further development of a GPS/GALILEO based mobile guide, useful visualisation methods, the development of a robust pedestrian analysis and prediction model and a concept for sustainable recreation planning, while two National Parks do not only offer different test sites, but also bring their expert view on typical visitors requests, as well as national park operator requirements specification for the analysis and prediction tool to the project.

In order to gain knowledge over the spatial and temporal distribution of national park visitors and their individual behaviour observations are made by the use of surveys, travel reports and pervasive sensors such as light barriers, video systems, pressure, heat or infrared sensors that are installed at specific points along the route network. However these methods gain only low resolution and low entropy information about a persons` spatio-temporal behaviour.

The only way to collect the individual movements in a sufficient quality is by the use of GPS enabled devices. First attempts to use GPS as monitoring technology for park visitors for spatiotemporal analysis and modelling showed the possible high practical impact for park management. [1 2]
Therefore the national park visitors are equipped with a GPS receiver and the GPS tracks are collected on a central server for further analysis. In order to convince national park visitors to use such a GPS device we follow a two tier strategy: on the one hand an easy to use GPS enabled mobile guide is developed,

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[1] Arrowsmith, C. and Chhetri, P., 2003, Port Campbell National Park: Patterns of Use A report for the development of visitor typology as input to a generic model of visitor movements and patterns of use. Department of Geospatial Science, RMIT University, Melbourne, Victoria

[2] Morris, S., Gimblett, R., and Barnard,K., 2005, Probabilistic Travel Modeling using GPS Data. International Congress on Simulation and Modeling, Melbourne, Australia, Dec 2005.

which offers location and time based information to the visitors while at the same time tracking their routes. (see Fig. 1) On the other hand visitors act as mobile "measurement units" through the usage of the mobile guide and provide GPS position data with high resolution. This tracking information is anonymously transferred to the analysis and prediction tool, which delivers easy to use information for the national park management about the spatiotemporal visitor behaviour on an aggregated manner (e.g. preferred routes, travel length, duration, stops, etc.). (see Fig. 2)

At the same time the prediction tool feeds back information to the visitor and offers routes according to the visitor's preferences, e.g. sending her to an area less crowded, which still offers the spots (flowers, animals) he wants to see most. Moreover the visitor can assess his own collected information via an online diary that shows his route and spatial information along this route together with pictures or audio files he has collected during his visit.

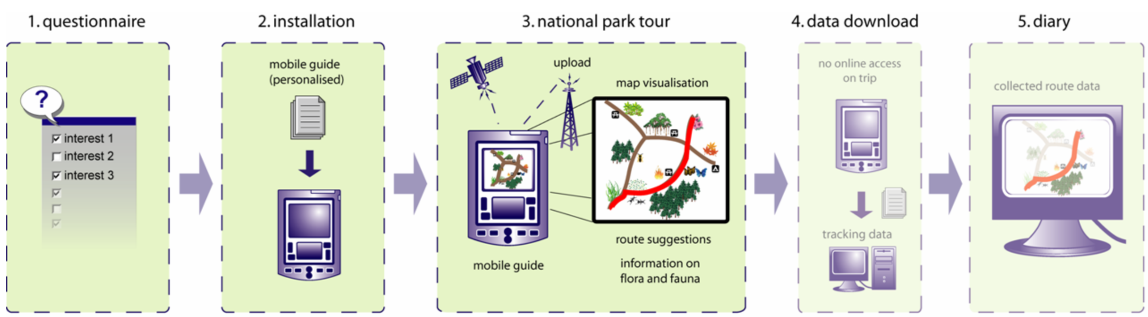

Fig. 1. Benefit for the visitor by using the GPS enabled guide.

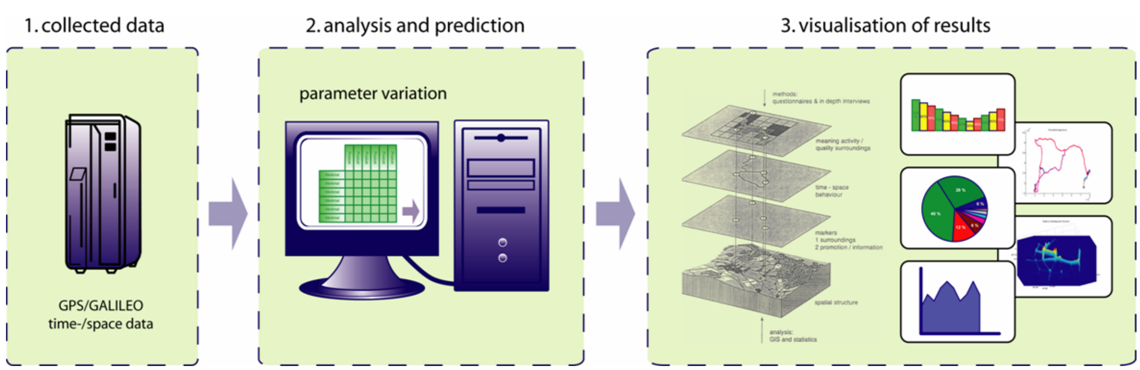

Fig. 2. Benefit for the national park operators based on the collected GPS data

2.1. Data collection, analysis and visualisation

As it cannot be assumed that all visitors will use a mobile guide, additional people counting techniques at entrances and fixed locations complement the satellite based measurements. To analyse the GPS data it is pre processed with outlier detection and map matching methods. Afterwards several analysis algorithms are applied to discover the required information such as preferred routes, travel length and duration, stops and duration and visitor frequencies at certain route segments. Different information is combined to understand the spatiotemporal behaviour of the visitors: e.g. by comparing the stop analyses results with the geo referenced places of interest the popularity of certain areas in the park is measured and by analysing the adjoining route segment the popularity of specific tours can be derived. The information is fed into a spatiotemporal analysis tool that enables the park management to examine the acceptance rate of thematic routes and places of interest and revise the routing strategy if necessary. The national park operators can make spatial and temporal restrictions and will get the spatial visitor distribution in the centre map containing the path network showing the visitor frequencies of the individual path segments and at the entrances. Also the frequencies at places of interest and analysed stopping areas can be displayed. So it is possible to determine popular places and the attractiveness of them over time and with regard to the current visitor groups. Typical analyses are trip length and duration, stop duration, speed distribution and number of visited places.

2.2. Movement prediction, information feedback and validation

The GPS position and counting data sets are combined with the actual meteorological data (actually the even more complex parameter of the "felt temperature" is included into the model) and provide the basis for prediction models, where future visitor counts and routes are estimated. On the basis of large long term data sets a reliable prediction tool will deliver planning information to the park management taking into account actual weather conditions and seasonal dependencies. The model is currently developed and will be implemented until autumn 2008.

The models will be used by the national park management to create new routes and offer real time information and dynamic route changes to visitors who rent a GPS enabled PDA.

3. Conclusion

The general idea behind the described project was to turn the data that is collected via sensor network into valuable information that can be used to influence people's behaviour. A crucial point was to find a method to motivate people to share their movement patterns with the national park management and understand how they will benefit from the information that is fed back to them. This has worked surprisingly well: 245 people used the GPS enabled PDAs during a test time of two days – even though no real time information about the park could be provided.

The first part of the project has focused on evaluating and implementing data acquisition methods and developing analysis algorithms. Currently the prediction model is improved, benefiting from the constant stream of counting data. However more and constant GPS data is needed to evaluate the prediction accuracy of the model. In the second test phase the individual spatio-temporal motion behavior will be closely monitored in order to analyse the willingness of the visitors to follow the suggested routes.

4. Motivation for Participation in the Workshop

While more sensors deliver an abundance of data about the environment which can be used for a multitude of different control and guiding measures it is not clear yet how to balance the needs of the individual with the needs of a community or a society.
The typical problem in transport lies in car navigation where it has to be decided whether to integrate all possible streets into the maps or whether to keep some of them hidden in order to protect residential areas from through traffic or to make sure emergency services find less frequented routes.

In the described project in Vienna the aim is to give national park operators the possibility to get insight into their visitor's spatio-temporal motion behavior with the ultimate aim to influence their route choice. At the same time visitors make their personal data (GPS tracks, interest profile) available to the national park operators because they benefit from individual route information tailored to their interest profile. At the same time the users do know that in order to protect the nature they will not be guided to completely off – beaten tracks. It is part of the project to analyse the willingness of the visitors to balance their individual benefit against the benefit of the society.

This aspect of balancing needs and information and the willingness to alter behavior I would like to discuss in a workshop that aims at employing pervasive computing to protect the urban atmosphere.

5. Biography

Katja Schechtner is the head of Human Centered Mobility Technologies at arsenal research. Her team focuses on capturing, analyzing and simulating human mobility behavior. She has studied architecture and urban planning at the Technical University of Vienna, Austria (2001) and Columbia University, NYC, USA. She also holds an MSc in economics and communication from the DUK, Austria (2004). Currently she is finishing her PhD in Urban Planning at the TU Vienna, Austria and the ETH Zürich, Switzerland with her thesis about "Ambient Urban Intelligence". She has worked as an urban planner in The Netherlands, Ireland and as a senior consultant in urban planning and transport telematics in Japan.

TerraPed: A Design Concept for Sustainability

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Abstract
TerraPed is a design concept for an emergent, data-driven online world that is dependent on the ecological impact of humans in the physical world. This project has been conceptualized as a resource and tool to encourage a shared understanding of human impact on the earth by offering a visualization of that impact. Though standard ecological and carbon footprint assessments are helpful in communicating one's personal impact, these surveys do not encourage continuous monitoring or change to one's habits. TerraPed offers an engaging and informative platform for informing and motivating users to take action and change behaviors that threaten the sustainability earth's resources.

1. TerraPed Overview

TerraPed is an interactive, online community that emerges from real-world data and encourages its inhabitants to consider their ecological impact on the environment. This project measures the ecological and carbon footprint of each user and visualizes this impact in the form of a dynamic footprint graphic. Each inhabitant's footprint is in constant flux and is impacted by a live stream of data from an RSS news feed, location-specific air quality sensor data and the changes in lifestyle made by each inhabitant. Inhabitants are encouraged to: a) make lifestyle changes to limit the amount of resources they use; b) submit photos of themselves taking steps towards a more sustainable lifestyle, such as recycling, taking public transportation, or using alternative energy such as solar or wind power; c) engage daily and interact with current news and policy worldwide; d) motivate social interaction and participation to employ a collective intelligence towards positive environmental change.

Because those who are already concerned with environmental issues would most likely adopt a project of this nature, the main goal would be to engage people who wouldn't ordinarily interact with such issues. Therefore, an example of an ideal audience for this project is school children between the ages of 5-12 as part of their daily curriculum. The children would be encouraged to participate with their parents at home, introducing both children and adults to important environmental concerns and encourage changes throughout the entire family.

Additional functions and applications would be built into TerraPed after the initial implementation of the online component. These additional components would encourage use by a broader audience and include a mobile phone application for real-time monitoring of one's footprint, as well as a Facebook Footprint widget. The Facebook widget would encourage a larger audience to participate in the TerraPed community, as well as add an element of social and environmental consciousness to Facebook.

1.1. The TerraPed Experience

The TerraPed experience begins with a simple registration, in which users are asked to create a username and password, and to provide their zip code. The username and password is used to access personal footprint information and the zip code is used to provide location-specific information and suggestions about local resources. After a user registers, they are asked to complete an Ecological and Carbon Footprint Survey. This survey integrates the basic questions of both types of standard surveys and provides the users with calculations represented numerically, as well as in the form of a footprint. They will also receive an image of an ideal footprint and a representation of the national average for others in their country of residence. This footprint is placed onto the emergent planet in the center of the main page. As more users register, all will populate the planet with a variety of footprints viewable. Personal footprint information is accessible only to individual users, unless each user specifies open access to their social network.

Once a user's footprint is established, inhabitants are encouraged to make lifestyle changes towards a more sustainable existence, as well as find a balance between personal impact within their control and external impact beyond their control. The ultimate goal is to reduce the size of their footprint to the ideal sustainable size determined for their country of residence. For example, the ideal human footprint for the US is 4.5 acres of land for each person, but the a average footprint is 24 acres of land and 7.5 tone of carbon dioxide. If one's footprint were determined to equal 14 acres of the earth's resources and 5 tons of carbon emissions, their goal would be to take steps towards reducing their footprint and CO_2 emissions to 4.5 acres and zero tons of carbon in the US.

All changes to individual footprints are visualized by a change in size and color, as shown in Figure 1.2.3. These changes occur based on personal impacts, air quality sensor data and a RSS news feed related to climate change and environmental issues. Personal impact is measured by the lifestyle habits outlined in the footprint survey as well as through a shared photo stream of inhabitants take steps towards sustainability. This shared photo stream encourages users to take photos of them recycling or taking public transportation, and invites other users to vote for and comment on the impact of others actions, adding a social element to promote participation and shared ideas. The idea of creating a social and informational network for environmental sustainability is consistent throughout TerraPed, and acts to motivate its users to take action.

1.2. Graphic

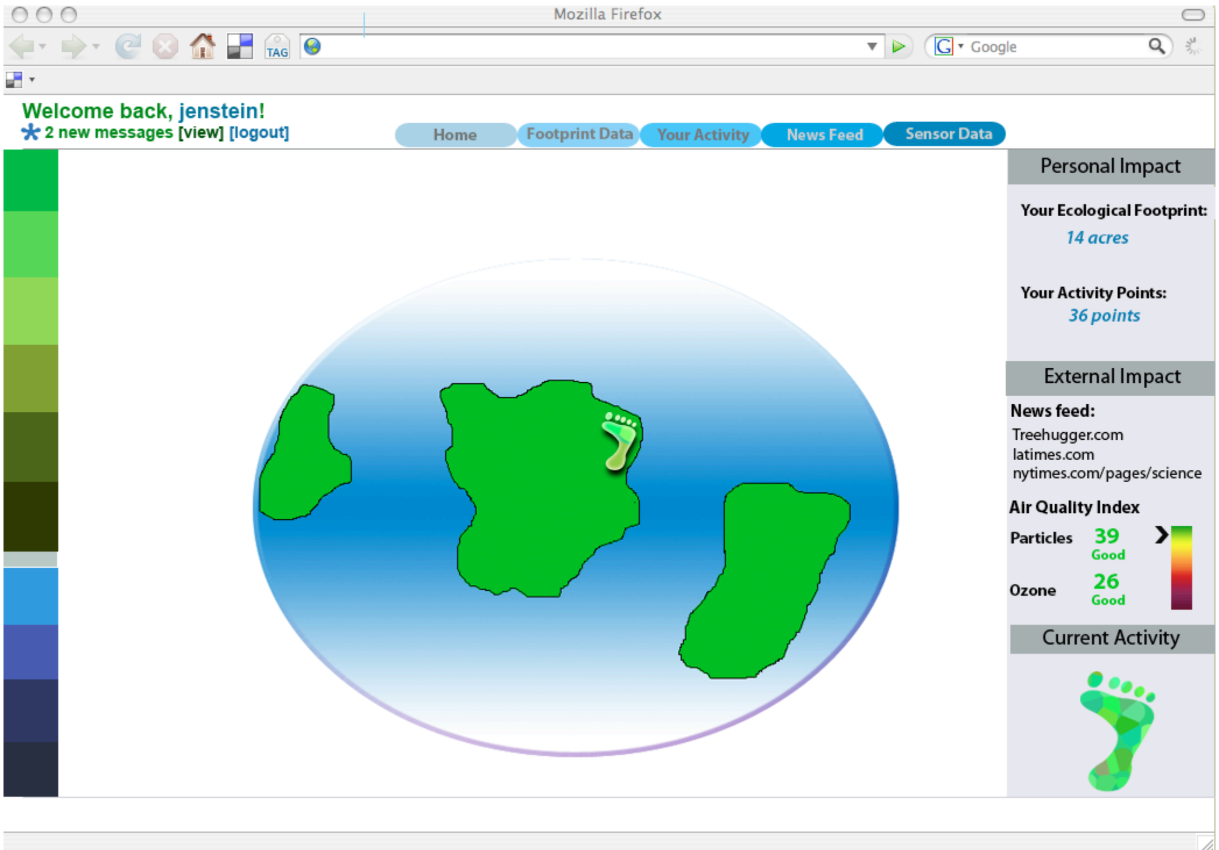

Figure 1.2.1 Main page

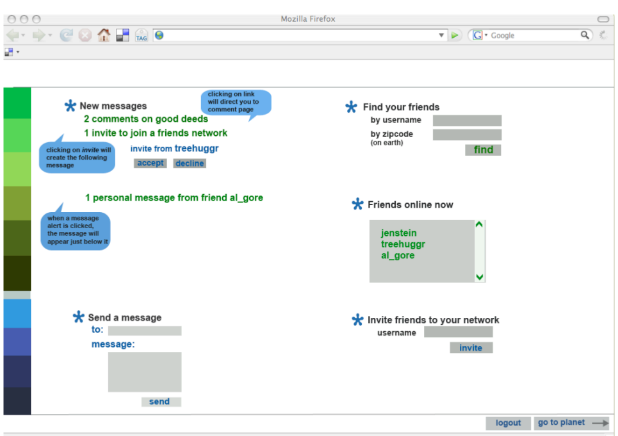

Figure 1.2.2 Social Network page

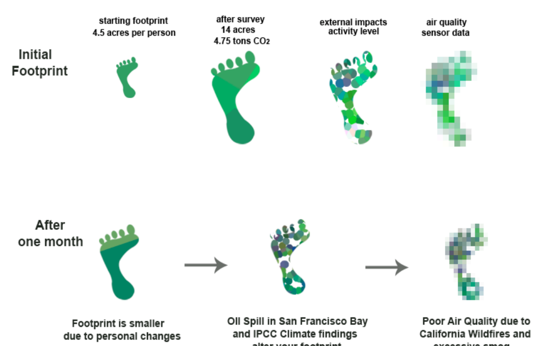

Figure 1.2.3 Data-driven changes to footprint

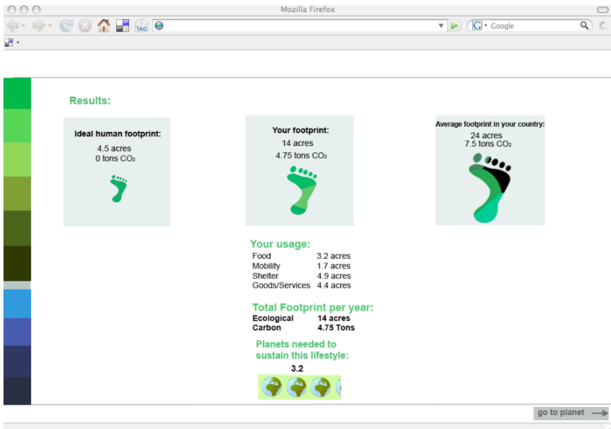

Figure 1.2.4 Results page

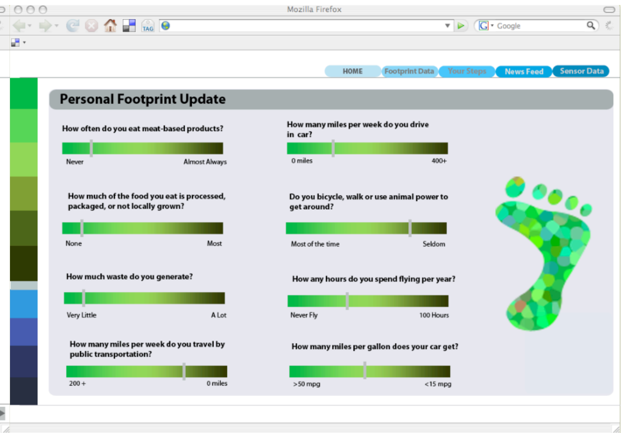

Figure 1.2.5 Footprint Update page

2. Summary

TerraPed's main goal is to educate people about their impact on the environment and motivate them to take action. This includes making lifestyle changes such as decreasing the amount of carbon they create or the amount of energy they use, while making people aware of the consequences of where their food is grown, how much waste they create, and what they can do to change these habits. By offering a dynamic visualization of one's personal ecological and carbon footprint, along with a social platform to share ideas and information, TerraPed presents a new way to engage people with issues of climate change and environmental sustainability.

Biography

Jennifer Stein is a doctoral candidate in the newly created PhD program in Media Arts and Practice in the School of Cinematic Arts at the University of Southern California. As the focus of this program is on both theory and practice, Jennifer's research will examine the impact of urban computing on the spaces of everyday life and interaction design informed by this research.

Prior to entering this program, Jennifer was the Program Manager of the Interactive Media Division in the School of Cinematic Arts, where she developed curricula for a graduate program, advised students, and managed several research grants. Before coming to USC in this capacity, Jennifer completed my Master's Degree in Media and Communications from Goldsmiths College, University of London. She has also worked in new media and television production in New York and Los Angeles at Nickelodeon and Warner Brothers.

Motivation

My motivation for attending this workshop is to share ideas with a like-minded community about how to motivate towards change and what tools would be most beneficial to reach this goal. Because I hope to integrate themes of sustainability into my doctoral research and design projects, I believe this workshop would be an invaluable experience.

CHALLENGING COMFORT & CLEANLINESS NORMS THROUGH INTERACTIVE IN-HOME FEEDBACK SYSTEMS

Yolande Strengers

Abstract
This paper discusses the limitations of targeting individual behaviours through information feedback systems without considering the broader socio-technical context in which decisions are made about how people use energy and water. The paper draws on recent research conducted by the author investigating the impact of interactive in-home feedback systems on practices dependent on comfort and cleanliness norms. The research found that although current feedback systems were doing little to challenge bathing, laundering, heating and cooling practices dependent upon these norms, feedback systems could be redesigned to target normative behaviours. This conclusion is made within the context of previous research on social norms which has found that people will be more likely to change their behaviours if they are benchmarked against a wider social group and given approval or disapproval for their current behaviours.

Previous research shows that personalised feedback can achieve energy and water consumption savings of between 5-15 per cent [6]. However, larger gains have arguably not been achieved because information feedback does little to challenge practices that are deeply ingrained in social and cultural norms.

This paper briefly summarises recent research conducted by the author on the impact of interactive feedback systems on comfort and cleanliness norms, which largely govern practices such as heating, cooling, bathing and laundering. The paper offers preliminary conclusions to suggest how feedback systems can challenge normative practices. This analysis is made within the context of the researcher's PhD, which is exploring how interactive energy and water technologies, such as 'smart meters' and 'in-home displays', influence expectations of comfort and cleanliness in Australian households.

Figure 1: Ampy Email's EcoMeter

The research discussed involved a range of ethnographic methods, such as interviews, household tours, observation and photography, with ten households from South East Water's 'EcoPioneer' trial based in the south-eastern suburbs of Melbourne. The full trial involved 50 households, which each had an Ampy Email 'EcoMeter' in-home display system (see Figure 1). The EcoMeter plugs into any power point in the home and displays the household's energy, water and gas consumption in real-time. The research aimed to understand how feedback systems affect expectations of comfort and cleanliness, and how they could be re-designed to challenge these norms more strongly.

Normative behaviours are those which sit beyond the realm of questionable practice [13] and are so deeply ingrained in the routines of daily life that education alone will not result in their reconfiguration [9]. This is despite the fact the histories of everyday practices such as laundering, bathing, heating and cooling show dramatic variations in what is considered 'normal' [1, 4, 5, 11, 18]. For example, while a weekly bath was recently the norm, this has been replaced by daily or more frequent showering. Similarly, comfort practices such as opening windows, cooling the body with water, using blankets and appropriate clothing, or building thermally efficient housing, are being replaced by heating and air-conditioning [13].

Although many other norms influence individual behaviours, water and space heating and cooling (comfort norms) constitute almost 60 per cent of Australians' energy demand in the home [7]. Similarly, the bathroom, toilet, laundry and kitchen (cleanliness norms) constitute 70 per cent of an average household's water consumption in Melbourne [12]. However, governments, utilities and conservationists have been reluctant to challenge these norms. Shove [13, p. 17] argues that this is because 'comfort and cleanliness constitute fine examples of non-negotiability, their meaning and importance being quite simply taken for granted.' The EcoPioneer research supported Shove's conclusion and attributed the lack of change in these norms resulting from the provision of feedback to two factors.

Firstly, the research found that householders either didn't understand or misunderstood the connections between the consumption data provided through the EcoMeter, and their own practices. They were left to answer questions such as: what practices does this figure on my screen relate to? And, is this figure appropriate or inappropriate for the tasks I have just undertaken? This problem is related to the way the consumption data was provided to participants, which was in the units of kilowatts, kilolitres and greenhouse gas emissions. Providing raw consumption data to householders assumes that they can understand and translate this information into energy and water services, such as air-conditioning, heating, lighting, showering, cooking and computer or TV usage [13, 14, 18, 20].

Secondly, the practices made possible by energy and water are set within wider social and cultural norms governed by notions around what it means to have a clean body, clothes or house, or to be comfortable in any given society or culture [13]. Feedback systems generally target the individual, rather than this larger context in which a household is situated.

Therefore, where householders had made the connection between their consumption data and practices, they did not necessarily consider these tasks to be negotiable or changeable. Instead, they often tried to improve the practice by changing the technologies used for the task. For example some participants changed to water-efficient showerheads or energy-efficient light globes (provided to all participants taking part in the EcoPioneer trial). Similarly, most participants made small efficiency changes to their practices such as taking shorter showers, doing full loads of laundry, or turning off lights and standby appliances. However, feedback rarely resulted in fundamental changes to householder norms around what it means to be clean or comfortable. Residents rarely showered or washed their clothes less, or suddenly tolerated a larger band of temperatures, although some did use the heater and air-conditioner less.

The non-negotiability of these practices can be attributed to two main factors. Firstly, many people shower once or twice a day and wear fresh clothes everyday because they believe society expects them to, and because this expectation becomes habitualised into daily life. The thought of embarrassing or disrespecting oneself by wearing dirty clothes or giving off body odour is generally reprehensible, and indeed many people find their own body odour repelling, although this has not always been the case [13].

Secondly, comfort and cleanliness expectations are being ratcheted upwards by a whole range of actors. For example, heating and air-conditioner manufacturers, electricity providers, governments, fashion designers and builders are all involved in both directly and indirectly promoting artificially-produced comfort [13]. People conform to these escalating expectations and come to regard them as normal, rejecting former and alternative ways of achieving them.

Providing isolated information to households about their energy and water consumption therefore falsely assumes that people can meaningfully translate this information into practices and make autonomous decisions to substantially change them independently of their social context [18]. These findings confirm the views of several other authors [2, 15, 17, 19], who argue that individuals are not always free to act on information that is provided to them. Instead, individuals are constrained and influenced by technologies and infrastructures around them, the way resources are provided, and the social and cultural norms of the society they live in. While the EcoMeter encouraged participants to make small changes to the technologies and infrastructures in their homes, it rarely challenged their expectations of comfort and cleanliness.

Feedback systems could be redesigned to challenge these norms in a number of ways. Firstly, feedback systems should encourage greater social interaction, both within and beyond the household, by improving the prominence and visibility of the in-home display system. Social interaction around the EcoMeter was already occurring in some of the homes visited, and this encouraged debate about everyday practices such as laundry and showering. Within the household, it gave the members with lower comfort and cleanliness expectations (mainly males and children) the opportunity to challenge householders with higher expectations (mainly females), who tended to dictate the overall standard of the household.

Having the in-home display in a prominent position can also encourage discussion about practices that depend upon social norms with people visiting the household, such as what each person would or would not be willing to change to achieve a reduction in energy and water use. Several interviewees reported this occurring as a result of the EcoMeter and noticed that householders with high expectations of comfort and cleanliness tried to conform to the norms of their peers and family members. While this approach can backfire and reinforce or increase existing expectations of comfort and cleanliness if the social group in question has higher expectations than the target household, the conservation focus of the in-home display biases discussion towards practices that save energy and water.

To reinforce this approach, normative information could be provided through the feedback system. This might involve benchmarking people against a wider social group, such as their neighbours, in addition to indicating some form of approval and/or disapproval for their consumption levels through the display system. Several psychology researchers have tested this approach with great success [3, 8, 10]. They found that people aspire to the norm of any given group they belong to, as well as respond to an approval rating provided by the managers of the feedback system (which reinforces an aspired social norm).

Although this paper has argued that subtle changes could be made to feedback systems to encourage a greater reduction in energy and water consumption, norms are unlikely to change overnight. Feedback systems are still heavily focused on individuals, and largely ignore the wider technological and institutional context in which individuals are contextually situated. For example, feedback systems designed to challenge comfort and cleanliness norms have to compete with the dominance of the shower, the proliferation of air-conditioning, and universal clothing standards in the workplace. Therefore, it would be foolish to promote feedback systems as a 'solution' to environmental problems without considering it a small part of a wider socio-technical system of energy and water consumption [13, 16].

Author biography

Yolande Strengers is currently undertaking a PhD research project within the School of Global Studies, Social Science and Planning at RMIT University in Melbourne. Her PhD is funded by the Australasian CRC for Interaction Design (ACID) and the Australian Housing and Urban Research Institute (AHURI). Yolande is supervised by Dr Anitra Nelson and Professor Mike Berry from AHURI Research Centre at RMIT University. She holds a Bachelor of Arts (Deans Scholars Program) from Monash University and is due to finalise a Masters of International Urban and Environmental Management at RMIT University in the near future.

Motivation for attending workshop

Yolande is interested in attending Green Pervasive because the first workshop theme is closely aligned with the aims of her PhD research. In particular, Yolande is interested in understanding how pervasive technologies can assist in challenging normative behaviours.

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Taking the Guesswork out of Environmentally Sustainable Lifestyles

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Abstract
A large number of global environmental conferences, protocols, pacts and inter-governmental panels have been doing some excellent work in providing long-term guidelines, regulations and credible data for making decisions as well as for actions needed. However, a majority of these are geared towards large organizations such as governments or corporations. There is a considerable potential for impact by targeting individuals and providing them with relevant information to induce small incremental steps that can collectively result in large impacts. The focus of this paper is to identify ways and means wherein pervasive sensor-based technologies can assist individuals, who are unaware of global environmental protocols, in making daily decisions which can result in an environmentally sustainable lifestyle. Specific scenarios are discussed which explore the use of existing technologies where feedback can be provided to an individual for his/her actions. This feedback could use real-time collaborative data as well as historical trends and averages.

1. Introduction

1.1. Daily Lifestyle Trends In Energy Consumption

The use of energy in daily life is unavoidable. It is important to understand energy use distribution by end use in order to understand where the largest savings impacts are possible by user intervention. In the United States, the Energy Information Administration (EIA) provides data, forecasts, and analyses to promote sound policy making and public understanding regarding energy and its interaction with the economy and the environment. Looking at electricity consumption by end use in US households closely reveals that household appliances, including refrigerators account for over 50% of US household energy use[1]. Equipping the end users and/or appliances with energy meters as well as communications capabilities can be a first step in providing feedback to users.

This is where pervasive networks with distributed sensors can provide significant benefits by way of providing feedback to individual within households as well as by making these data available to a larger database to progressively improve the rigor in policy making and implementation. Coupled with real-time feedback to users about the environmental impact of their usage patterns (amount of

[1] **U.S. Energy Information Administration**, from
http://www.eia.doe.gov/emeu/recs/recs2001/enduse2001/enduse2001.html, accessed 2008-01-05

resultant carbon emissions, etc.) *and* concrete suggestions to reduce their impact, there is a significant potential to achieve widespread and radical levels of impact reduction.

2. Using Pervasive Ad-Hoc Networks for Making Environmentally Sustainable Lifestyle Choices

2.1 Current Applications of Sensor Based Networks

Buildings have long used sensor-based Building Management Systems (BMS) or Energy Management Systems (EMS). A BMS/EMS is typically defined as a fully functional control system, which includes sensors, controllers, various communications devices and the full complement of operational software necessary to have a fully functioning system[2]. In addition, there are also industry-accepted data communications protocols such as BACnet[3] (Building Automation and Control Networks), that have been designed to meet the communication needs of various building systems and the information is made available to building operators and facility managers.

However, with the increased interest in green buildings and the resulting need for providing feedback and education to users; there are some products/systems that are more geared towards providing building users/occupants with real-time feedback on the reduced environmental impacts of buildings that have been designed as green or energy-efficient[4]. These products typically tie in with building automation and control systems to provide feedback to users/occupants. Furthermore, wireless applications too are coming to the fore[5]. At a larger scale, Automatic Meter Reading (AMR) is gradually and increasingly being adopted by utilities and offers exciting possibilities in the context of this discussion. From UtiliMetrics[6], AMR is the remote collection of water, gas and electric consumption data from customers' utility meters using remote sensing technologies.

2.2 Use of Pervasive Technologies to Encourage Action and Change.

The first step in making sustainable lifestyle choices would be to provide the end users with a simple, easy to understand view of their energy consumption as described in 1.1. Simple energy meters are available[7] that can measure "Watts" used by various appliances (dryers, water heaters, air-conditioning, etc) and can make a cumulative reading. These can be easily extended to provide a SMS alert or an email at every periodic time interval (every 24 hrs) to the end user. This would enable the user to get an accurate idea of their energy consumption. Similar energy meter readings collected from a community in the same neighbourhood and hence having similar space heating and cooling requirements can provide energy usage patterns and comparisons to the members of

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[2] See **DDC Online**, http://www.ddc-online.org/intro/intro_chapt01.aspx for a description, in generic terms of "Direct Digital Control" systems; accessed 2008-01-05.

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[5] See ArchRock – Applications for Environmental Monitoring on http://www.archrock.com/applications/, accessed 2008-01-06

[6] See Utilitmetrics – About AMR on http://www.utilimetrics.org/about/amr.htm, accessed 2008-01-10

[7] See Kill-A-Watt devices made by P3 International, http://www.p3international.com/products/special/P4400/P4400-CE.html; accessed 2008-01-06.

that community in a collaborative manner. These comparisons can also provide classification based on the type of appliances used and their specific brands, to help determine the most effective and energy-efficient appliances. An intuitive user interface and easy to understand information is imperative in enabling the end-user to take relevant action. Devices like MorePower Multi[8] are possibly the next generation of "smart-energy meters" which provide actionable and easy to understand information. To make this more actionable, such a system maybe enhanced so as to provide examples of simple everyday actions and how they can reduce energy use, costs and emissions, on a daily, monthly and annual basis; without compromising quality of life, such as running your refrigerator on the "Medium-Low" setting (typically 3-4°C), instead of the "High Cool" setting (typically 1°C); running your hot water at 50°C at opposed to 55°C; changing all your light bulbs to compact fluorescent lamps, etc.

A logical next step to collecting data and information is to analyze the same and to determine how it compares to that of the people around. A fair amount of information is available on personal carbon trading, such as the RSA CarbonLimited project[9].

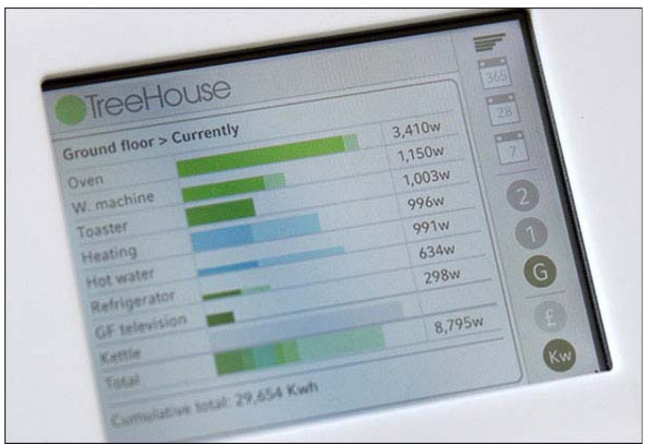

Figure 1: Image MoreAssociates

According to the U.S. Environmental Protection Agency (EPA), typical annual CO_2 emissions due to electricity are 16,290 pounds (7.39 metric tons) per household, assuming approximately 900 kWh per month, while typical annual CO_2 emissions of 11,000 pounds (4.99 metric tons) per household based on national average monthly consumption of 7,680 cubic feet of gas; amounting to a total of 27,290 pounds (12.38 metric tons) of CO_2 emissions for household energy use[10]. In comparison, annual emissions from a typical passenger vehicle are estimated at 5.5 metric tons of CO_2 emissions[11]. Given the nationwide average of nearly two vehicles per household[12], vehicles can be seen to contribute as much to household emissions as electricity and natural gas.

An extension to the household energy meters is to fit vehicles with "mileage meters". These meters show the mileage given by the car over a short period. The mileage data of the car as well as of the cars driving around it can be made available to the driver using vehicular networks. The advantage

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[8] See MoreAssociates energy literacy, http://www.moreassociates.com/research/energy_literacy, accessed 2008-01-06.
[9] Carbon Limited, exploring personal carbon trading, from http://www.rsacarbonlimited.org/viewarticle.aspa?pageid=577&nodeid=1; accessed 2008-01-06.
[10] http://www.epa.gov/climatechange/emissions/ind_assumptions.html; accessed 2008-01-10
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[12] http://www.bts.gov/press_releases/2003/bts019_03/html/bts019_03.html; accessed 2008-01-10

of providing real-time collaborative data would be to provide the end-user with information which is relevant and specific to the vehicles which are being driven in the same environmental and road-conditions but providing better mileage. This can lead to a competitive outlook to getting the best mileage possible. This is similar to a multi-player video game where the statistics for each user are displayed on the screen and the players try to better their games based on the opponent's scores and skills.

About the authors:

Ronak Sutaria is an Entrepreneur at Urban Sensors and a Senior Engineer with Arcot Systems. He has travelled nationally and internationally as a technical solutions architect and has extensive experience with enterprise-level e-commerce applications. He has a Master's degree in Computer Science from the New Jersey Institute of Technology where he did his thesis in the field of Anomaly based Malicious Code Detection and took courses in Advanced Networking, Mobile Computing and Sensor Networks. He has peer-reviewed papers for the ICPS 2006 and worked, in an academic capacity, with technologies such as TinyOS, nesC, Maté and Trickle. He has a keen interest in applications of sensor based technologies to urban cities in developing countries.

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Motivation for attending the Pervasive Persuasive Technology and Environmental Sustainability workshop:

The conference is addressing a lot of the real-world sustainability issues. The idea of motivating people in real time to take action based on concrete data is very appealing. The use of pervasive technologies in such a scenario, if made intuitive enough, seems very plausible. The authors also have a keen interest in making these technologies viable and accessible across the economic divide.

The hands-on and interactive nature of the workshop seems like an excellent platform to understand the current knowledge base of the participants on these topics as well as brainstorm new realistic ideas. The idea of keeping the participants engaged beyond the workshop is especially exciting. The design challenge 2009 would be an interesting exercise to know how practical some of the ideas are and to be able to collaboratively design some of these prototypes.

ECOISLAND: A SYSTEM FOR PERSUADING USERS TO REDUCE CO_2 EMISSIONS

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Abstract
A significant portion of the carbon dioxide emissions that have been shown to cause global warming are due to household energy consumption and traffic. EcoIsland is a computer system aimed at persuading and assisting individual families in changing their lifestyle patterns in a way that reduces CO_2 emissions. The system builds on our earlier work on persuasive ubiquitous computing applications, and applies ideas from behaviorism, social psychology and emissions trading to attempt to motivate changes in users' behaviour. In this paper, we briefly describe the concept and the theories behind it, and provide preliminary results from a user study measuring its effectiveness.

1. Introduction

According to Intergovernmental Panel on Climate Change [1], global warming caused by greenhouse gases released into the atmosphere through the actions of man is a major threat to the earth's ecology. Efforts to reduce greenhouse gas emissions come in two forms: technological solutions and changes in human behaviour. Technological solutions broadly include improving energy efficiency and developing cleaner energy sources. Dramatic changes in human behaviour may also be necessary if catastrophic climate change is to be avoided.

Public and private efforts to change individual behaviour towards more environmentally friendly practices usually rely on education, but there are psychological limits to the ability of education alone to effect behavioral change. Even when a person well knows that a particular behavior is so detrimental to their long-term well-being as to offset any possible short-term benefits, their may still irrationally choose the short-term indulgence. Future consequences, while widely known, are easily ignored in the present.

In our earlier work on *ambient lifestyle feedback systems*, we used ubiquitous computing technology to construct a virtual "Skinner box" to motivate children to adopt correct tooth brushing patterns [2]. The system monitors the user and rewards desirable behaviour using techniques familiar from computer games, while punishing undesirable behaviour. This approach may be described as falling in the general field of *captology*, computers as persuasive technologies [3].

In *EcoIsland*, we apply a similar approach to attempt to motivate behaviour changes that reduce CO_2 emissions. Compared to the earlier work, *EcoIsland's* design is informed by a richer psychological theory and includes a complete "virtual economy" for emission rights trading. The purpose of the work is to study the applicability and effectiveness of these techniques for persuasive purposes.

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2. The EcoIsland concept

EcoIsland is a game-like application intended to be used as a background activity by an ecologically minded family in the course of their normal daily activities. A display installed in the kitchen or another prominent place in the household presents a virtual island. Each family member is represented on the island by an avatar (Figure 1). The family sets a target CO_2 emission level (e.g. national average minus 20%) and the system tracks their approximate current emissions using sensors and self-reported data. If the emissions exceed the target level, the water around the island begins to rise, eventually sweeping away the avatars' possessions and resulting in a game over.

Figure 1. EcoIsland main visual

On their mobile phones, the participants have a list of actions that they may take to reduce the emissions: turning down the air conditioning by one degree, taking the train instead of the car, et cetera. Upon completing an action, a participant reports using the phone, and the water level reacts accordingly. Reported activities are also shown in speech bubbles above the corresponding avatars. A lack of activity causes the avatars to suggest actions.

Participants can also see neighbouring islands and their activities in the display, and can list buy and sell offers for emission rights on a marketplace. Trading is conducted using a virtual currency obtained from a regular allowance. The credits are also used to buy improvements and decorations to the island, so successful sellers can afford to decorate their island more, while heavy emitters have to spend their allowance on emission rights.

3. Persuasive techniques

The general approach from ambient lifestyle feedback systems is to provide a feedback loop for user behaviour. The virtual island shown in the display acts as a metaphor and makes the participants conscious of the ecological consequences of their choices and activities.

We also tap into social psychology, attempting to exploit *social facilitation* and *conforming behavior* to encourage the desired behaviour. Social facilitation is the phenomenon where a person performs better at a task when someone else, e.g. a colleague or a supervisor, is watching [4]. Conforming behaviour is the desire not to act against group consensus [5].

EcoIsland's design facilitates these by involving the whole family, and by presenting the participants' activity reports in the speech bubbles and providing contribution charts and activity histories. On the other hand, the fact that the game is played by a family unit instead of an individual means that participants can also agree to assign tasks to certain members.

Lastly, there is the trading system, which is based on the same principle as industry level emissions trading systems: reductions should be carried out in places where it is easiest to do so. A family that finds it easy to make significant reductions can sell emission rights to households that find it difficult due to e.g. location or job. This should make it possible to attain the same amount of total reductions with a lower total cost (measured in disutility), promoting use of the system.

4. Implementation

We have developed a prototype system that implements the functionality described above, except that sensors are not yet used. Figure 2 presents the overall architecture and technologies used. The kitchen display uses Adobe Flash to render a visualisation based on data obtained from a server running the *EcoIsland* application, which is written in Java. The mobile phone clients use a normal web browser to interact with the server. The application is of the thin-client type: data is managed in a database on the server side, so that the client machine stores no data.

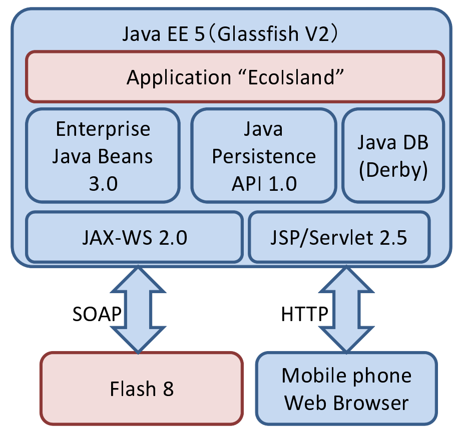

Figure 2. EcoIsland system architecture

5. Evaluation

For our first user study, we recruited six families (twenty persons) who are interested in environmental issues and live in a family. The experiment lasted for four weeks. In the first week, we equipped the participants' air conditioners with a simple *Ecowatt*[6] electricity usage meter to compare the readings between experiment weeks.

In the second week, the system was installed and only one family member from each household was asked to use it. In the third week, all family members used the system. Comparing the results of the second and third week provides insights regarding the social psychological effects. In the fourth week, we introduced the emissions trading system, and observed how it affected user behaviour. After the experiment, we conducted a survey in the form of a questionnaire asking about changes in the participants' attitudes and feedback.

6. Results and Discussion

In the survey, 17 out of 20 participants said that they were more conscious of environmental issues after the experiment than before. Several families said that the sinking virtual island contributed to a change in their consciousness, suggesting that the metaphor works well. But when asked about their motivations for the emission reducing actions they conducted during the experiment, they responded with reasons stemming from the system, such as wanting to save the sinking virtual island, purchase items and amass points, rather than using environmental reasoning.

A log of the emission reduction activities reported by the participants shows that five out of six persons reported more actions in the third week than the second week, lending support to the hypothesis that social facilitation and conforming behaviour can be used effectively. During the fourth week, only two out of six families used the emissions trading system. Ten participants reported that the target reduction levels were so easy to achieve that there was no need to resort to emissions trading. This highlights a common challenge in game design: how to set the parameters (in this case, target levels, effect of actions and currency allowances) in such a way as to provide an optimal challenge.

As for the air conditioner electricity usage recorded by *Ecowatt*, there was no observable correlation with the reported emission reducing activities. While this is an alarming result, it does reflect the fact that the experiment period was short considering ordinary day-to-day variance in electricity use. The time of the experiment (in December and January) was also such that the appliance may have been used less than normally. In the future, *EcoIsland* could be linked to a HEMS (Home Energy Management System), which would allow for a large variety of usage data to be automatically reported to the system, also enabling a much more comprehensive evaluation. However, some participants noted that the act of manual reporting itself probably contributed to the motivation, so we must be careful when replacing self-reporting with sensor data.

Work on *EcoIsland* continues, probably in the form of a larger and longer user study that among other things tries to provide an evaluation of the trading system. At the same time, we plan to apply this particular flavour of persuasive technology to other application areas.

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