Embedded WiSeNts

Information Society Technologies

IST-004400

Deliverable 3.2:
Visions for Innovative Applications

and their Social, Legal and Ethical impact

EW Identifier: EW-T32-UCAM-002-07-VISIONS
Date: 14-12-2006

Author(s) and company: George Coulouris and Marcelo Pias, assisted by Adam Wolisz, Vlado Handziski, Thiemo Voigt, Laura Marie Feeney, Nirvana Meratnia, Maria Lijding, Paul Havinga, Sebnem Baydere, Anibal Ollero, Paul Couderc and Michel Banatre.

Work package/task: WP 3 / T 3.2
Document status: final
Confidentiality: public
Keywords: Visions for innovative applications and their Social, Legal and Ethical impact, Applications for cooperating objects

Abstract: This whitepaper explores visions for application areas and their technical scenarios that could potentially be realised once a wide-ranging technology of cooperating objects becomes available. It furthers the discussion with an analysis of the social, legal and ethical impacts of such visions.

Table of Contents

Abstract

Embedded Wisents devised a roadmap that will accelerate European research in the area of wireless sensor networks and cooperating objects. An important part of the roadmapping is to identify appropriate directions that fully recognise and address the social and ethical impact of cooperating object technologies and their future applications.

This whitepaper explores visions for application areas and their technical scenarios that could potentially be realised once a wide-ranging technology of cooperating objects becomes available. The focus here is on longer term visions that are clustered around a 10-year horizon. It furthers the discussion with an analysis of the social, legal and ethical impacts of such cooperating object's applications.

1. Introduction

This document is structured as follows. First, we examine emerging technological basis for future application scenarios, including ideas from ubiquitous computing, embedded sensor networking, and cooperating objects. This information is derived from relevant technical experts and presented in Section 2, and in much more detail in the WiSeNts Research Roadmap [9]. The technical vision is one in which heterogeneous, loosely coupled systems interact with each other and the environment.

Second, we explore the broad application areas for these emerging technologies. A systematic technical survey of ongoing research in this area was done in the WiSeNts studies D3.1.1, D3.1.2, D3.1.3 and D3.1.4. The process of envisaging future possibilities for applications based on these technologies was opened to a broader audience in two contests where participants submitted short essays describing future applications. A large number of submissions covering a broad range of topics from social interaction to environmental monitoring were received.

Section 3 presents a brief overview of these contests. The range of application areas seen in the submissions, along with highlights of some of the most interesting entries are discussed in Section 4.

Third, we examine the social implications of such applications. We shared the results of the work above with distinguished experts in this area and held an exciting and highly interactive workshop on social, legal and ethical implications of future cooperating objects applications. The workshop is briefly introduced in Section 3 and its results discussed in Section 5. The full report can be found in Appendix D

The workshop highlighted eight main areas in its study of legal social and ethical implications of cooperating object technology. Major issues included: privacy; responsibility for the behaviour of these systems, given the complexity and unpredictability of autonomous interactions between humans, system and environment; ease of use and the digital divide problem; environmental sustainability; and the role of government and industry.

The conclusion was that a variety of legal and technical approaches was required and that it was important to consider these issues early in the development of future systems.

Finally, in Section 6, we use these three sources of input - *technological, application oriented, and social implications* - to consider issues for future visions. We suggest key issues for future technical development and examine the technical and other implications of potential roadblocks raised in the social workshop in the context of cooperating object' applications.

2. Technology

The classical concept of embedded systems as a control system for some physical process (e.g. machinery, automotive industry) has been recently revisited. Two new technical developments emerged and support the notion that systems based on very small communicating computers are likely to have significant socio-economic impact on our society in the next decades.

2.1. Ubiquitous computing

A vision originally described by Mark Weiser in [8] is one where omnipresent computers serve people in their everyday lives at home and at work. It aims to develop systems that sense and interpret the state of the world and human activities in order to enhance the human experience. Current ubiquitous systems range from the nearly imperceptible ones that control lighting, heating, ventilation and physical security in indoor environments to hand-held interactive devices that automatically provide relevant information to users as they move around their homes. Systems are context-aware and adapt to changes in the environment.

Some more extensive applications developed in laboratories now working in ubiquitous systems indicate the potential benefits of ubiquitous computing. Such systems are constructed from networks of computers that can be carried, worn and installed pervasively in indoor and outdoor spaces. Their sensors enable them to detect their location and observe the state of their environment, whereas their actuators interact with environment and with human beings. Collected data about the state of the environment and its users are then further processed and knowledge can be discovered.

Sensors could measure force, sound, light, temperature and most other physical and chemical parameters. Such measurements can be used, for example, to detect human presence and activity, monitor air quality or determine vital signs and other parameters in healthcare. Sensors that acquire visual images are not excluded although their analysis and interpretation is currently limited by the image processing required and its resource costs.

The GAIA project at the University of Illinois [1] gives an interesting perspective for the future technical infrastructure of ubiquitous computing. Physical spaces become interactive systems, or in other terms, Active Spaces. Such environments are analogous to traditional computing systems; just as a computer is viewed as one object, composed of input/output devices, resources and peripherals, so is an Active Space. However, the heterogeneity, mobility and sheer number of devices makes the system vastly more complex. Applications may have the choice of a number of input devices such as location sensing system, mouse, pen, or finger and output devices, such as an everywhere display, monitor, PDA screen, wall-mounted display, speakers, or phone.

In contrast, the European Commission through the ISTAG group put forward the vision of Ambient Intelligence (AmI)[2], which is similar to the Weiser's ubiquitous computing idea. In AmI applications

[1] [GAIA project web page, University of Illinois, Urbana, IL. http://gaia.cs.uiuc.edu/]
[2] http://www.ercim.org/publication/Ercim_News/enw47/intro.html

people will be surrounded by intelligent and intuitive interfaces embedded in everyday objects and environment recognising and responding to the presence of individuals in an invisible way.

The ubiquitous computing and Ambient Intelligence visions strive for user-friendliness, efficient services, and support for enhanced human interactions with systems working in background, invisible to the users.

2.2. Wireless Sensor Networks

Even current handheld and other mobile computers are at least an order of magnitude too large for most of the scenarios envisaged for ubiquitous systems. And even if they were smaller, their cost, management demands and power consumption are incompatible with their deployment in the extremely large numbers required by many of the application scenarios.

Several research projects initiated around the year 2000 have developed extremely small, low cost and energy-efficient free-standing computers with a wireless networking capability suitable for deployment in large numbers. These sensor devices which sense and actuate in their environment not only operate individually, but collaborate together using ad-hoc communication to achieve a well-defined goal of supervision of some area or a particular process.

The most important of these developments was the 'mote' concept originated at the University of California at Berkeley. The name was coined to indicate that they can be regarded as a sort of 'smart dust' (dictionary definition: mote = something, especially a bit of dust, that is so small it is almost impossible to see). The products to date from these projects should be regarded as large-scale prototypes for the much tinier versions that can be expected in the coming years. Miniaturisation with MEMS fabrication is advancing with the goal of producing complete devices with dimensions of a few millimetres - small enough to be embedded in everyday objects or distributed throughout the environment with a cost of 0.5 Euros or less. We expect the Moore's law of doubling the number of transistors on an integrated circuit every 18 months to continue its trend. Although, nanotechnology developments will be required to solve the complex engineering problems in producing chips of sizes of nanometers.

2.3. Cooperating Objects

The classic concept of embedded systems combined with the notion of pervasive and ubiquitous computing and wireless sensor networks as systems that act and react on their environment are rather diverse systems. They create a coherent group of objects that need to *collaborate* to reach a common goal.

The conception of a future-proof system would have to combine the strong points of all three system concepts at least in the following functional areas [9]:

- control of physical processes as embedded systems are capable of doing today;
- have as good support for device heterogeneity and spontaneity of usage as pervasive and ubiquitous computing approaches have today;
- be as cost efficient and versatile in terms of the use of wireless technology as wireless sensor networks are.

The new system of *cooperating objects* consists of individual intelligent and state-full entities or objects that jointly strive to reach a common goal, which involves sensing or controlling of devices, and are dynamically and loosely federated for cooperation. A paradigm shift is envisaged with this vision. Systems will change from passive single agents instruments to pro-active cooperating agents.

The future development of cooperating objects support the broad vision of Sentient Computing put forward in the early 1990s[3]. This is the proposition that applications can be made more responsive and useful by observing and reacting to the physical world. It is particularly attractive in a world of mobile users and ubiquitous computers.

3. Methodology

Longer-term application visions clustered around a 10-year horizon are needed to offer motivation and provide a context for the evaluation of technology proposals in cooperating objects research.

We began the work for this study by eliciting long-term application visions from the participating partners in the Embedded WiSeNts project at an internal workshop. This yielded a useful initial set of application scenarios that are amongst those reported in this document. But we were aware from the start that although the design of cooperating object systems would require significant expertise and commitment, the originators of the visions and scenarios that precede them need not have an immense depth of technical knowledge. Indeed there is a risk that such expertise may obscure or limit their vision. For this reason, the process of envisaging future possibilities for applications based on cooperating objects was opened to a broader audience in two specially-organised Embedded WiSeNts open contests in which participants submitted short essays describing future applications.

In these events, a large number of submissions covering a broad range of topics from logistics to environmental monitoring were received. It is our view that a substantial proportion of them merit further study. Of course any such technology-based visions inevitably have a substantial risk of encountering roadblocks in the intervening years. The roadblocks may be due to lack of technical capabilities or to social, legal and ethical constraints.

For the purpose of comparison of our emerging visions with those of others, we examined other expert studies from the literature on the future of sentient systems and cooperating objects [6, 10, 3, 4].

Finally, in order to identify the social implications of the visions that emerged from these activities and multidisciplinary research issues emerging, we shared the results of the above work with distinguished experts in that area at our final major event, an on-invitation workshop on social, legal and ethical implications of future cooperating objects applications.

The remainder of this section gives an overview of the three main events that were organised by the Embedded WiSeNts project in support of the Visions task:

- WiSeNts summer school competition (small-scale).

[3] Active Badges and Personal Interactive Computing Objects, R. Want, A. Hopper, IEEE Trans. on Consumer Electronics, Feb. 1992. Andy Hopper, Sentient Computing - abridged and updated version of the Royal Society Clifford Paterson Lecture, 1999. Computer Systems: Theory, Technology, and Applications: A Tribute to Roger Needham, Series Monographs in Computer Science, Pages 125-131, Springer, December 2003.

- The Sentient Future Competition (large-scale).
- Workshop on Social Aspects of Cooperating Objects Technologies.

3.1. Open Competitions

To elicit many of the visions reported here, we organised two open contests. An 'Application Visions' competition was held at the Embedded Wisents Summer School on Wireless Sensor Networks and Smart Objects, August 29 - September 3, 2005, Schloss Dagstuhl, Germany.

28 entries were received from the participants in the school. The winning entries and several others were considered of high quality by the judges. Thirteen, including the two winning entries are reproduced in Appendix A. The WiSeNts consortium sponsored the prizes for the first (high-end Apple iPod) and second winners (low-end Apple iPod). The competition was locally administered in Dagstuhl by members of the Embedded WiSeNts (ETHZ and University of Stuttgart).

This contest was seen as a useful precursor to a major competition entitled *The Embedded Wisents Sentient Future Competition (SFC)*. This was sponsored by Deutsche Telekom Laboratories with a generous donation of €10,000 for prizes. The competition was administered by members of the Embedded Wisents team with some external assistance in the judging phase.

The SFC competition was launched on 1 October 2005 with website, email and press publicity. Entries were invited with a closing date of 30 November 2005. The competition announcement, rules and results can be found in Appendix B.

The rules were kept as open as possible to encourage entries from a wide cross-section of people. We hoped that the competition would attract entries in many different formats and styles from ordinary members of the public across a range of disciplines and different countries.

The SFC competition attracted 79 entries in total. Judging was performed in two phases:

1. All entries were reviewed by a panel of 25 reviewers drawn mainly from the Embedded Wisents partners together with three industrial reviewers from Deutsche Telekom Laboratories (Germany) and Ubisense Ltd (UK). Each entry was reviewed by at least three reviewers who assigned a score based on four multiple-choice questions and added a short personal comment.

   Using those reviews and the aggregated scores, all entries were ranked and the top 25 were examined by two Embedded WiseNTs personnel to check for consistency in the reviewing. Then 6 entries were selected based on their scores and review comments for the 'short list', which was used in the second phase. Also, further 7 entries were selected to be mentioned as 'commendable'.

2. In the second phase, a panel of seven experts (four leading members of the Embedded Wisents team, one other distinguished academic and two industry experts) were each tasked to prepare a ranking for the 6 entries on the shortlist. They were also offered the option to include items from the 'commended' list. Finally, this panel held a telephone conference to reach decisions about the award of the three monetary prizes.

We are very grateful to all of the reviewers[4] for their careful and diligent assessments and especially to the members of the final judging panel for their time and effort dedicated. The entries were

[4]The list of the reviewers can be found in Appendix B

evaluated against the criteria of originality of concept, innovation and technical progress, and impact - social, economic and environmental. The panel announced the final results on the 15th January 2006. Prizes were awarded in a special session of the European Workshop on Sensor Networks (EWSN) 2006. Full details of the winning visions and other high-quality entries can be found in Appendix C. We summarise below the winner lists of both competitions. The next section reviews a selection of the most important visions collected from all sources including the open competitions.

Dagstuhl Summer School Competition:

- **1^{st} SCC: Small Child Care** *Zinaida Benenson (RWTH Aachen, Germany)* Category: Health Care.
- **2^{nd} Sensor Pearls** *Matthias Gauger (University of Stuttgart, Germany)* Category: Environmental Monitoring.

Sentient Future Competition:

- **1^{st} Large Scale Body Sensing for Infectious Disease Control** *Markus Endler (Pontifica Universidade Catolica do Rio de Janeiro, Brazil)* Category: Healthcare.
- **2^{nd} BIN IT! The Intelligent Waste Management System**

  . David Schoch (University of Zurich, Switzerland), Matthias Sala (ETH Zurich, Switzerland) Category: Environmental Monitoring.
- **3^{rd} Vision of Congestion-Free Road Traffic and Cooperating Objects**

  Ricardo Morla (Lancaster University, United Kingdom) Category: Transportation.

3.2. Social Workshop

The socio-technical goal is to achieve the smooth and reliable integration of humans and cooperating object technology. To achieve this, we need to understand the social, legal and ethical implications of such an inter-activity within future application scenarios.

Cooperating object applications reveal a set of multi-disciplinary design issues in areas that cross the engineering, social sciences, law, economics and psychology. The configuration of cooperating objects at the engineering level is focussed on efficiency and usability with the assumption of fixed functionality and generalised user.

In contrast, the design issues for social scientists and lawyers relate to the social adaptation of technology which can be explicit with handling of user expectations, control of situations and acceptability of systems.

To this end, we sought help of experts from social sciences, law, economics and psychology to expand on the visions in order to identify plausible scenarios and add social, legal and ethical impact evaluations of them. The help came in the form of on-invitation workshop held on the 1st and 2nd November 2006 in Berlin. The International Workshop on Social Aspects of Cooperating Objects Technologies was organised by the Centre for Technology and Society at Technical University of Berlin [5].

[5] http://www.embedded-wisents.org/workshop/

The social, legal and ethical issues that resulted from the discussion of the workshop are presented in Section 5.

4. Overview of Application Visions

108 applications entries were received in total from the open competitions. Out of this, we provide an overview ordered by application areas from the entries we consider are most interesting and could potentially affect the direction of research in the next years. These applications were also scored high by the judging panels of the competitions.

Whenever it is appropriate, we contrast the WiSeNts visions (identified in bold face and fully described in Appendices A, C with those envisaged in [6, 10, 3, 4].

We used the taxonomy proposed in WiSeNts Study *D3.1.1 - Applications and Application Scenarios*. Since this taxonomy addresses applications that can be understood today, we felt the need to extend this set in order to deal with some longer-term visions. We added new areas namely *human augmentation* and *enhancing social interactions*. The former refers to all the ubiquitous cooperating object technology that can be employed to assist our daily activities. The latter area uses cooperating objects to establish or maintain social relationship among people.

4.1. Control and Automation

Cooperating objects would help to enable various forms of automated and distributed process control in indoor or outdoor environments. It is the vision of the next generation of organisations with focus on bridging physical world and the digital information space [3, 4].

The **Monitoring Tape, see Appendix B** vision is a long-term application which requires extremely small hardware in order to easily monitor the conditions of structural materials in bridges and buildings. The tape is easily applied to the area of interest, making construction and preventive monitoring accessible to everyone. There is a risk for using this system to spy on things or people if the sensors are tampered with to gather information on its immediate surroundings as opposed to the monitored structure itself. The sensory system is comprised of sensors capable of exchanging information with other neighbouring sensor systems.

Focus on hardware design of specialised sensors and their miniaturisation is expected in order to realise visions in this area. The development of software frameworks for energy-aware data collection should follow closely the sensor development. Although cooperation to achieve autonomous decisions is a major challenge, it is required in some of these visions.

4.2. Home and Office

These applications aim at improving the well being and space usage at home and office through the gathering of context information.

A key aspect for the design of a future sentient computing application is to provide ambient intelligence for non-expert users. Automatic, self-organising and self-managing systems will be essential for such ubiquitous environments, where billions of computers are embedded in everyday life. The vision of **Ambient Intelligence by Collaborative Eye Tracking** gives some technical insights on subconscious social interactions and indicates directions when other communication is inappropriate. Integration of eye tracking and sentient technology will create a powerful paradigm to control and navigate applications.

In contrast, K. Pister [6] envisages a similar scenario where houses and offices will be aware of our presence, and even orientation, in a given room. Lighting, heating, and other comforts will be adjusted accordingly. If someone is looking for a conference room, they will know which is the nearest available . And if someone is in an unfamiliar building, lighting will guide them, for instance, with a ribbon of arrows on the floor or the walls, annotated with the name of the room they are pointing to, and colour coded if there are two lost people whose paths may cross. Sensors are easy to defeat though, so security of these systems is a major roadblock for this vision.

Other visions, with more technical focus, describe a platform for globally-distributed cooperative sensing that would enable the development of novel applications at unprecedented scales. The **Cooperative Sensing** envisages the fusion of sensors with the omnipresent portable communication devices (mobile phones, PDAs, etc.) and network enabled personal electronics (music players, digital photo cameras, camcorders, etc.). On the assumption of massive penetration of this technology to the general members of the public, simple sensing capabilities will yield useful applications without significant impact on the cost of the devices.

Real-time algorithms for signal processing are needed. This may impose high bandwidth and processing power requirements in scenarios of low-resource cooperating objects. Location services including reliable and accurate localisation schemes for emergency situations need to be in place. Much more effort has to be put into the information processing side, where novel techniques for information fusion, outlier detection, and distributed calibration have to be developed. They should combine the multitude of low-quality sensory information into meaningful representation of the physical reality. These software systems need to be context aware with considerable attention to security and privacy issues.

4.3. Logistics

Visions in this application area foresee that the majority of goods and even some services sold in the market will be trackable from their production line to the delivery. Sentient systems will track the product throughout its life, sensing or reading data about its producers, the production methods used and the environment. It adds further information to each product including the identity of the main producers with their hourly wages, work required for the production and also any airborne sprays detected during the process. The products themselves will trigger alarms in case thresholds are reached (e.g. storage temperature above the limit).

This not only assists the inventory management for the food industry but also helps the monitoring and control of the quality of food. Government agencies, for instance, could receive reports of food recycling. What is most important all these tasks could be performed in real-time.

Fair trading could be realised and verified for products produced by people in third world countries to ensure that producers receive fair reward for their labour and investment (see the **Validated Fairtrade** scenario). To work properly, this scenario ought to have the right type of incentives otherwise entities in the chain can circumvent the validation system (e.g. switching off the sensors).

Another vision outlines a scenario where utilities will be differentiated by placing low cost wireless sensors into taps, lights, switches, heating systems and appliances. Utility companies could provide itemised billing and a whole host of value added services, well-being monitoring and remote control that might even allow the utilities to remotely enable/disable selected devices for whatever reason (please see the **Smarter Utilities** scenario).

The **Smart Labels** vision has some aspects that can be developed today and others that require further research. The basic idea is to make value chains – including production and inbound logistics, outbound logistics, sales and marketing, as well as maintenance and recovery – smarter by using smart labels, and particularly to overcome incompatibilities at the transitions from one phase to the other. These labels should include sensors for acquiring information about their environment.

A large number of mobile sensor systems are expected to communicate in these scenarios. Distributed location schemes need to be developed to avoid the overhead issues of a centralised back-end system. Fault tolerance is an important issue to be addressed. Further research and development on sensor design is required. In particular, small Micro-Electro-Mechanical Systems (MEMS) sensors that can sense chemical and meteorological conditions of the environment in which the product was produced. They should be embedded in flexible labels, similarly to the current RFID tag systems.

4.4. Transportation

Visions in this category should address the safety of road users and pedestrians. Often the envisaged sensor systems would gather data for real-time or ”close” to real-time information services provided by governmental agency and private organisations including insurance companies.

K. Pister [6] envisions that vehicles will be fully aware of the road conditions on a user’s favourite route home, not at the level of some traffic announcer telling that it is slow on a given motorway, for instance, but with detail of the instantaneous speed and history of every vehicle between the user and their destination, as well as the ones that are likely to get on the road, should the user choose to look at that detail. Most likely the user’s agent software will just tell which route to take, and how many minutes it will take.

Similarly, some of the visions received from the open competitions describe scenarios where co-operating vehicles will be aware of dangers and pro-active in making semiautonomous decisions. Proactive safety systems will be in place in every car. The co-operation will allow sensors in each vehicle to monitor the environment condition with in-loco air quality measurements (e.g. nitric oxide, carbon monoxide, etc). The Kyoto protocol will be supported by extensive monitoring of gas emissions - a required task to make our environment more sustainable. The EC ISTAG reports [3, 4] detailed a similar vision to make transport in Europe more economically, socially and environmentally sustainable. This requires the commitment of different sectors of the society including travellers (they may need to change their behaviour), manufacturers of vehicles to equip them with the latest traffic and pollution monitoring and road safety technology, and the government in the investment and management of transport infrastructures.

Traffic congestion in urban areas will be mitigated by advanced congestion-based charging which will be supported by pervasive distributed traffic monitoring system. The **Supportive Road** scenario (see Appendix B) put forward a scenario where sensors installed on the roads assist in various traffic applications including road congestion avoidance and safety of drivers. Also, a few non-critical applications will emerge allowing people to exchange their favourite audio tune with other vehicles travelling together.

Similarly, the long-term vision **Congestion-Free Road Traffic** takes a step further to propose a technical solution to address traffic congestion. It explores the concept of dynamic time-space corridor that can be negotiated between cooperating vehicles to guarantee congestion-free journeys from departure to arrival.

To fully address the safety of road users, the technology should be developed to all road users. Consider the case that a system in a vehicle after exchanging information with other vehicles to avoid a collision, instructs the driver that an action should be taken, say turn to the left. Such a decision would not make sense if other vehicles (e.g. motorcycles or bicycles) and even pedestrians were not part of the decision making process.

Towards this goal, the **Sentient Guardian Angel** proposes the use of wireless sensor networks to address dangerous traffic situations for elderly pedestrians, children as well as for disabled persons. Communication between the networks of the participants is used to detect the threat at an early stage giving adequate warnings using suitable audible/visual actuators, alerts and instructions to the ones involved.

Keeping records of a vehicle's service history is always important for re-use of vehicles. An used car, for instance, could give a detailed list of the parts that have been replaced or repaired over the course of its lifetime [5]. Other information such as the amount of gas emissions could be added to this list so that sellers could get commercial advantages due to any reduced historical gas emissions, which is likely to be taxed higher in the future.

Significant investment in technology and infrastructure is required. The cost of instrumenting road infrastructure may be apportioned by governments and private organisations such as insurance companies for keeping information on drivers driving history. Privacy is a major concern here and will be analysed in Section 5.2.

These scenarios present a different system perspective than the current transportation applications surveyed in the WiSeNts study *D3.1.1: Applications and Application Scenarios*. Unlikely the ad-hoc and infrastructure-less characteristics, some of the visions call for a pre-established infrastructure of sensor nodes deployed in major roads. For instance, base stations every 1 to 5 Km and high-bandwidth backbone network. The sensor systems vary from one scenario to another but it would include vehicle passing detector, structural material integrity, motion sensors and video capturing systems. Actuators are also discussed in a form of vibration, audible and visual (e.g.s LEDs). Most of such an information should be provided in real-time. In some scenarios, a third-party may be needed to establish trust relationship between consumers and companies.

4.5. Environmental Monitoring

Environmental monitoring applications are of crucial importance for the scientific community and society. Thousands of square kilometres of geographical area may be supervised and duration of this can be years. Application scenarios envisage that cooperating objects will monitor vegetation growth and air/water quality (see **Pearl sensors**), oil spills and will coordinate (e.g statistical sampling and data filtering) to create a big picture of natural spaces. Because of the large-scale aspect, natural disasters such as prominent flooding and earthquakes could be anticipated through improved models of the global environment. Authorities would be alerted and actions taken quickly to respond to natural disasters. More sensors will tell accurately what the weather will look like.

Plantation swarms would be monitored individually or as a group and controlled to prevent outbreaks and disastrous economical losses that follow in the trail of, for instance, the desert locust in Africa and western Asia (see the **LocuSent scenario**). Invasive insects could be controlled in regions where they have no natural predators.

Also, the management of the population's waste could be efficient and sustainable leading to higher life quality and less costs for the city authorities. Financial incentives may be employed to encourage the correct disposal (see **BIN IT! The Intelligent Waste Management System**). Carbon emissions and absorption would be measured or estimated in order to charge/ration citizens according to their consumption. Individuals can receive carbon debits for their use of energy and carbon credits for clean energy that they generate, for example, by investing in wind farms and for carbon-absorption activities including trees and other vegetation planted or invested in. Carbon debits are then converted to a tax on the individual. The direct benefits are increased environmental and public health gains. There exist the risk, however, of privacy loss and fraudulent interference with sensor systems (see **Zero Carbon City** scenario).

Systems designed for these applications are to be very robust, and localisation is an essential task. Since the nodes are unattended in this class of applications, the system must be power efficient and fault tolerant. Furthermore, long lifetime of the network must be preserved while the scale increases in order of tens or hundreds, and solar panel for energy should be considered. With regard to sensor types, the following measurements should be considered: vehicle emissions, vegetation growth, monitoring of water quality, implantable sensors for animals, sensors for biochemicals , for instance, using Bio-MEMS (continuously in contact with the blood), gas emissions for forest fire monitoring - to cite a few.

4.6. Health and Fitness

Merging wireless sensor technology into health, medicine and fitness applications will make life much easier for doctors, disabled people, patients and overall population. They will also make diagnosis and consultancy processes faster by patient monitoring entities consisting of sensors. Those sensors will provide the same information regardless of location and automatic transitions from one network in a clinic to the other installed in patient's home will be available. As a result, high quality healthcare services will get closer to the patients. The benefits of this will be clear, although short-comings are expected too. For example, employers can demote employees based on an analysis of biomedical data (biosensors data and genetics information).

The European Commission through the ISTAG reports on the vision of well-being in the ageing society [3, 4]. The vision is the one where new paradigm of personalised healthcare will support EU citizens in living healthy lives, minimising time in hospital, at local doctors or in care homes. Europe's increasingly elderly population will be able to live more independently in their home environment. The service envisaged is pro-active where more personalised and preventive health care is employed as opposed to reactive methods such as treatment for the elderly.

The application scenarios foresee critical diseases diagnosed by means of tele-monitoring of individuals with specialised biosensors, with some of them implanted in the human body. K. Pister [6] goes further to envision that there will be no unanticipated illness. In his vision, sensor implants will monitor all of the major circulator systems in the human body, and provide the monitored individual with early warning of an impending flu, or save their life by catching cancer early enough that it can be completely removed surgically.

The **Intelligent Pills** vision envisages the scenario that patients swallow pills that activates upon reaching the stomach. The clear benefits are the efficient use of medicine, less waste, and better dose, tailored to the patient needs. The intelligent pill takes measurements of the level of chemicals in the stomach and blood and releases the optimal quantity of medicine needed to alleviate the symptoms of the patient. The pill is built of biodegradable material and it is small enough to be expelled from the body.

Small sensors and actuators in our clothes through smart fabrics will sense our physiological signals and movements in order to understand our health conditions. This should provide historical data to aid in achieving precise diagnosis. Computers should be able to interpret when we perform a physical activity, for instance, walking or jogging. Patients and doctors will be easily located inside hospitals.

Enhanced experience in fitness exercises will be achieved with useful feedback systems (e.g. audible and haptic) from tiny computers embedded in sports clothes and equipment. Entertainment systems for audio and video ubiquitous in mobile phones will be part of the overall body personal system. We will communicate with our clothes, watches and other accessories and they will cooperate with other user's cooperating objects.

An extension of the system will allow physiological signals of child's body to be constantly monitored from various points. Parents can make sure their children are thermally comfortable and healthy. (see **Body area sensor network for small children scenario**).

Within large-scale application, monitoring of infectious diseases may be possible. At first, cattle should be monitored with cooperating objects. The system will then be extended to humans at some point in time (see **Large scale body sensing for Infectious Disease Control**).

In this application area, localisation is an prime issue because it is critical to determine where the person is. The reliability and the minimisation of the delay between the source of the event, and the other end-point of the system is also important. The context and the person activity in the measuring time are also relevant. These applications should require minimal maintenance, use of biodegradable materials, and new biosensors. The energy harvesting from the body heat seems conceivable.

4.7. Security and Surveillance

Sensors and embedded systems provide solutions for security and surveillance concerns. These types of applications may be found in varying environments such as deserts, forests and urban areas - to cite a few. Communication and cooperation among networked devices increase the security of the concerned environment without human intervention. Natural disasters such as floods or earthquakes may be identified earlier by installing networked embedded systems closer to places where these phenomena might occur. The system should respond to the changes of the environment as quick as possible. Security and surveillance require real-time monitoring technologies with high security cautions. The mediums to be observed will mostly be inaccessible by the humans all the time and hence robustness takes an important place. Furthermore, maintenance may not be possible also in these applications and then power efficiency and fault tolerance must be satisfied.

The personal safety is improved with cooperating objects. K. Pister [6] envisages that personal belongings that are worth more than a few dollars will know their owner. The user will be able to find it whenever they want it. Stealing cars, furniture, or other valuables will be unusual, because any of a user's valuables that leave their house will check in on their way out the door, and produce a sound if removed without permission.

Another scenario addresses the issue of people carrying weapons and other potential hazards that could potentially lead to incidents such as terrorist attacks. It envisages that this could be monitored and detected by cooperating objects deployed within cities. Warnings could be sent to the police and people concerned (see **Human Security Network**).

4.8. Education, Training and Entertainment

A potential future application area is education. It is possible to provide more attractive lab and classroom activities involving cooperating objects. The scenario is characterised by a high dependency on the context. Activities will aim at merging embedded systems into the education methods. Thus, the systems must be cost effective, affordable by many users and should have a high degree of automation.

The **Self-learning Children** sensor network is a middle-term vision whose aim is to enable a person, for instance, to sit at the playground and let their children to play. The system should notify the parents only when situations that might possibly harm his children occur. The decision if a situation might be dangerous should be taken by the sensor network autonomously based on previous experience. Similarly, the long-term **Small Child Care** scenario creates a smart environment around a child, enabling trusted people including parents, teachers, doctors and police to gain information about the child and to interact with them by means of their surroundings. Parents will be able to locate their children with location systems and cooperating objects sewn into their clothes [5].

In the area of physical education, the UK Sesame project's vision[6] is one in which athletes and coaches are continuously provided with precise and relevant information about their performance, their body state and posture, presented in a form determined by sport-specific training requirements based on a careful analysis of coaching methods and coaches information needs.

4.9. Human Augmentation and Leisure

It refers to all the ubiquitous cooperating object technology that can be employed to assist our daily activities. The vision **Agnostic Algorithms of Creation** explore the possibilities of interference among two distinct but almost identical dimensions by letting things that happen in the virtual world to reflect themselves in reality.

A **Sensor Network for our Brain** is a long-term vision that proposes the possibility to better influence the storage of information and the communication in our brain.

[6]http://www.sesame.ucl.ac.uk

Finally, the **Father in Womb** vision considers to transport some of the mothers experiences as a pregnancy woman to the father, allowing him to follow the embryo growth, movements and sensations, providing mechanisms for interaction between both.

On the leisure side, the EC ISTAG vision [3, 4] on new media paradigms for digital leisure aims at developing new forms of content and experiences for global networks. The next 20 years is foreseen as the place for opportunities to embrace and support new forms of digital media which are more interactive and intuitive than the ones available today. In addition to the currents media forms - text, photos, audio and video - the future will reserve space for multimedia and multimodal experiences, including systems that evoke the sense of touch and smell, sights and sounds. These systems should support new forms of social interaction, novel means of creative and artistic expression.

4.10. Enhancing Social Interaction

Ubiquitous devices will present a reality enhanced with added textual and visual information to assist our daily activities (see the **Agnostic Algorithms of Creation**).

Individuals will know more about the personality type of other people through the cooperation of embedded sensory systems in our clothes and other accessories. Our social behaviour in a given situation and context will be profiled (see the **Personality Sensors** scenario). Our eyes and face expressions will be tracked and understood (see **Ambient Intelligence by Collaborative Eye Tracking**). Perhaps individuals will tend to interact more with other people.

Those applications falling within the previous category and this one pose new technical requirements including advances in wearability of tiny sensors and design of body implantable devices that are powered through energy harvesting. Cooperation is a challenge observed in scenarios for enhancing interactions among people.

4.11. Challenges Emerging from the Visions

The sections above discussed a number of ideas for future applications. The technical challenges one faces span across areas such as sensor miniaturisation, real-time data collection and feedback, ad-hoc cooperation - to cite a few.

The WiSeNts Roadmap [9] discusses such issues in detail. In particular, the Roadmap gives an overview of the social issues associated with the future use of cooperating objects. It made the observation that if things of daily use are part of cooperating objects or if cooperating objects can monitor the behaviour of people with various types of sensory systems the information on an individual becomes much more continuous and comprehensive.

In contrast, it also touches the problem of a big brother who knows everything about people who are then unaware of who knows what. If these and other social issues are not fully addressed it is very questionable whether or not cooperating objects will find broad acceptance.

This whitepaper adds further details on this issue with an analysis of the social, legal and ethical impact of cooperating object technology in future applications.

5. Social, Legal and Ethical Issues

The major goal of the social workshop held in Berlin in early November 2006 (see Section 3.2) was to identify and discuss the grand challenges emerging on the social side of the cooperating objects technologies, and related technologies like ubiquitous and pervasive computing.

The workshop covered a wide range of relevant social aspects within four thematic areas:

1. What are the expected implications for market structures and the basis of legal governance, especially concerning questions of privacy and security?
2. What do we know about user expectations and emerging practices of usage, and which methods are suitable to assess them?
3. What are the possibilities of designing human-machine-interaction in a reasonable way, especially when technical autonomy has to be balanced with the requirements of human intervention?
4. What are the possibilities of managing large scale distributed systems, if the involvement of humans is considered?

In what follows we provide an overview of these issues and potential directions for research to address them. In the following, citations to the workshop speakers' contributions are made by names in italic. Further details and full attributions can be found within the workshop report in Appendix D.

5.1. Relevant Technical Characteristics

We observe that most of the issues discussed within the above themes arise from a range of technical characteristics of cooperating objects. We will focus on autonomy, complexity and reliability.

Autonomy A cooperating object as technically defined in the WiSeNts Roadmap [9] is a single entity or collection of entities consisting of sensors, controllers (information processors), actuators or other cooperating objects that communicate with each other and are able to achieve, more or less autonomously, a common goal.

Such a definition implies a certain degree of autonomy which highly depends on the application domain. In semi-autonomy, systems provide information through advanced interfaces to assist users in their decision making process. In contrast, in fully autonomous scenarios, objects gather contextual information and make decisions on behalf of the user.

Decker discussed further the autonomy concept under three aspects, which are all tightly coupled and at various levels of abstraction. Technical autonomy refers to the ability of a machine to execute certain actions using its internal control system. The second level, personal autonomy, refers to the ability of individuals to perform actions in the area of reasoning, but not necessarily morally correct. The third level, ideal autonomy, is where individuals execute actions in the area of reasoning but referring to moral criteria.

IBM's autonomic computing vision closely relates to the first and second definitions. The vision is one in which the computing systems can manage themselves given high-level objectives from administrators [7]. This vision has biological connotation since human autonomic nervous system governs our heart rate, body temperature and other vital functions without the central control of our brain.

Complexity Complexity is believed to arise from the highly distributed nature of cooperating objects as heterogeneous systems that need to communicate and cooperate (semi- or) autonomously. The deployments of such systems will be either with some form of federated control or totally decentralised.

The interaction between objects may create systems that have no designer. Even when well-engineered subsystems are integrated, the outcome of the interactions among them can be unpredictable. One reason being that the number of system states increases exponentially with the number of systems integrated. The other is that cooperating objects may be required to inter-operate in circumstances that were not originally intended by their designers.

Weyer believes that this complexity generates new uncertainties and risks since the system can be out of control. He observed that the aviation industry is a pioneering sector of the society for issues of distributed control and its complexity. The major problem presented was the collision of airplanes, which remains an unresolved issue. A number of different systems are used in different countries, which makes inter-operability between them a hard problem to address.

Reliability The cooperating object systems should produce reasonably predictable outcomes within some defined thresholds, and steps outside the thresholds should be controlled. The unexpected behaviour of the system is an issue. Thus, reliability and dependability are major technical issues associated with complexity. These create social and legal implications.

Failures of cooperating objects are inevitable. Hildebrandt observed that the self-healing characteristic of fully autonomous systems [7] implicitly mean unpredictability by nature so that they need self-correcting of undesirable situations.

Another issue identified which can have an impact to the reliability is the rate of technology penetration. The road safety application is an example. Cooperating objects installed in vehicles may assist drivers in their decisions, which can be for instance braking, turning or reducing their speed. Other road users potentially without the technology should not be excluded from the decisions taken by the vehicles cooperating objects. They need to be part of the decision making process or otherwise it will be difficult to justify the system.

Restrictions due to hardware and power consumption mean that conventional reliability engineering techniques such as hardware redundancy will have limited applicability in future cooperating scenarios. Also, these objects are supposed to exist closely coupled with the environment and so will be subject to a wide range of largely unpredictable inputs and changes in the context.

5.2. Privacy

Cooperating objects used in the application areas discussed in this document can sense and actuate in the environment. To achieve this goal, these systems collect as much as data as possible as it may help to decide on the context now or sometime in the future.

But the privacy issue demands minimal data collection with well defined purposes for the period of time the data is deemed necessary. Because of this conflicting goal, it was observed in the workshop that ubiquitous cooperating objects and privacy are at odds.

Meints suggested that miniaturisation of devices to achieve the vision of cooperating objects will make it easier to hide systems but the issues of interaction and explicit consent would become intensified. Users must be informed and give explicit consent for data collection and processing under the data protection law in European countries.

To shed light on this issue, the following broad questions were raised in the workshop:

- Social aspect: how do people perceive privacy? In particular, do they really care about privacy? Are they willing to trade privacy for useful cooperating object services?
- Technical aspect: how do we achieve privacy within cooperating objects scenarios? Should privacy be an issue in the design space of such systems?
- Legal aspect: what policies should be used to protect collected personal data of individuals?

At the moment, the general members of the public do not seem to be concerned about privacy even with the fact that they are constantly monitored with CCTV systems literately anywhere in some European countries.

A vast amount of personal data are collected today with web-based systems. Google Mail holds personal data enclosed in email messages of their users and process it, for instance, to display context-related advertisements of sponsored products and services. Such data if correlated with the Google search results can certainly tell a lot about the user's personal life.

Users' perception of privacy may change in the future with higher penetration of cooperating object technologies. Users may become fully aware of the privacy issues as more personal data are collected from various sources.

Ben Allouch pointed out that some studies ordered by a few high-tech companies suggest that if people get more advantage out of a product or service they may not care about privacy. Although this is purely the viewpoint of a company striving to put their products in the market, it helps to set the context for the following question: is there a trade-off between privacy and benefits of technology?

Collecting medical and fitness training information could be beneficial to the individuals in order to early detect any disease. Because of this people may allow the disclosure of such information to other parties which could include employers. We may have to address the issue, however, that employers could be using medical data in their staff promoting or demoting decisions.

A similar scenario is the hypothetical example of 'pay-as-you-live' insurance that envisages companies which will calculate the personal health risks on the basis of monthly monitoring of data. Smoking a single cigarette would increase the premium, jogging in the park or gym decrease it [5]. As part of the service contract, the user would trade the privacy of their personal data for paying less premium monthly. Of course, this scenario raise ethical question for eligibility of insurance claims: what diseases should be covered by the insurer?

Scenarios of cooperating objects in transportation raise the question of whether vehicles should be allowed to track the position of other road users because of the necessary data communication for road safety and traffic management applications.

5.3. Responsibility and Liability Construction

Cooperating objects can sense and actuate in the environment adaptively. To achieve this, systems should communicate autonomously and achieve their goals reliably.

Further consequences of the technical characteristics of cooperating objects are:

- *Lack of transparency:* the cooperating objects are likely to be obscure with respect to processes, existing data and extracted knowledge. This issue is due to the physical miniaturisation of devices, the autonomy and requirement for hiding the complexity of the system from the users.
- *Shift of control:* the application scenarios can potentially shift power in our society, from the users to a set of (semi or fully) autonomous entities in the form of cooperating objects.

These two consequences make very difficult (or almost impossible) the task of identifying responsible entities in cases of system failures. Responsibility is the basis for legally *constructing liability*. Law experts believe this is a roadblock for the future development and commercialisation of such technologies.

Responsibility may dissipate within the application [11] or disappear completely due to autonomy, complexity and distributed/decentralised control. *Hilty* presented some case studies from the aviation sector to exemplify the issue. The first world's fly-by-wire airplane (A320) crashed into a forest in 1998 (Habsheim - France) because the computer assumed the pilots were trying to land, while they were making a low and slow-speed pass for an air show. The responsibility in this case was very difficult to establish. There was no single cause of the accident, all technical systems did exactly what they were supposed to do. In particular there were no coding errors in the software.

Hildebrandt offered a subjective explanation for why it may be impossible to establish responsibility. The ability of being aware of one's own consciousness is an important characteristic of humans. It is the rare capacity of humans to put things in perspective and reason about possible actions. Unlike humans, the researcher argues that autonomic computing objects that cannot reflect about their own actions cannot be blamed, everything the object performs happens via 'autonomic computing', i.e. without any central control. So how could someone construct liability in cases of system failures?

The problem of finding responsibility accentuates with autonomous control of robots. The common design practice today is for robot systems to be constructed as *black boxes*, which can only be assessed with reference to its overall behaviour. These objects normally learn using internal states and environmental information collected from their sensory devices. Within this, learning robots should be distinguished from those without machine learning capabilities because the use of learning algorithms might influence the liability for damages caused.

It is extremely difficult, however, to precisely gather the environmental context, especially in face of unforeseen circumstances. The technical question is how can robots anticipate and deal with them?

Should we ever reach the point where actions of a machine are unpredictable because of their learning systems and lack of transparency, the law may claim that no basis can be found to make the system liable to their actions.

5.4. Digital Divide

Cooperating object technology may accentuate the problem of digital divide, which is the gap between those with access to digital technologies and those without.

The issue of education is key here. People may be reluctant to access the technology even when it is made available to them. This seems to be a bigger problem in developing countries, which in some cases lack the fundamental education system for their children. Some may argue that in other countries, children are growing up with technology in their daily lives. This is a favourable situation to achieve technology-literacy.

A new dimension of this issue is the automated discrimination processes which means that those individuals with access to cooperating object technologies could face discrimination on the basis of income, race and social class. This creates a new issue which is a social divide but among those who use the technology. *Toepfer* exemplified this with the scenario where two users walk in an intelligent room. Both have different preferences for ambient temperature. While one prefers 18C, the other feels more comfortable with 22C. For whom should the system optimise the temperature - for the premium customer who pays more for the service, or should it reach a compromise? Other similar examples can be found in the home and office and transportation application visions.

5.5. Ethical issues

Ethics is referred to here as the moral principles for maintaining basic human rights and other social constraints. The fundamental question that arose from the workshop is how we can achieve the right balance between human and machine agency in order to prevent the rise of machines and the dehumanisation of users within the long-term applications?

This is a rather broad question which is pervasive to all social and legal impacts discussed above including privacy, liability, sustainability and justice to avoid the digital divide.

Although answers to these issues are rather specific to domains of applications and social-cultural contexts, ethics should be treated as the guiding question for a thorough discussion.

5.6. Sustainability of technology

The scenarios considered here envisage a large number of almost invisible computers cooperating to achieve a common goal. Once cooperating objects are installed, it will be difficult to replace them. For instance, sensors to measure trees health (see Zero Carbon City vision) will not be easy to be replaced. Not only is there the technical risk of making these systems work reliably but it could lead to major environment and health problems.

Hilty pointed out that some studies by Swiss universities concluded that pervasive computing might make the electronic waste problem almost intractable. There are three types of environmental impacts of the technology [11]:

- First order: effects of the physical existence of the technology
- Second order: indirect environmental effects due to its power to change processes

- Third order: environmental effects of the medium or long-term adaptation of behaviour or economic structures due to stable availability of the technology and services it provides.

Technological systems should not decay at the same rate as today. Technology needs to become sustainable. Today we throw it away and purchase new ones. Users will need to learn how to re-use technology in a modular way. Engineers need to design systems that can be re-used by combining pieces of existing systems. The approach of re-use could be implemented with loans of systems to their users as well. This could generate a cycle of use similarly to what happens in other sectors (e.g. vehicles). The issue of sustainability of technology needs to be tackled at the technical and political levels to be effective.

6. Conclusions

Scenarios for longer-term applications are needed to offer motivation and provide a context for the evaluation of technology proposals in cooperating objects research. This document discussed future applications and their social, legal and ethical impact on our society.

The open competitions provided a useful technique for gathering visions. The social workshop extended it with the identification of relevant social and legal issues that must be addressed in order to ensure the smooth and reliable integration of humans and cooperating objects in these applications.

The discussion revealed a set of multi-disciplinary design issues in areas that cross boundaries between engineering, social sciences, law, economics and psychology. More research is needed drawing on these disciplines in the design of distributed object applications. The requirements for research on the technical issues of cooperating objects are covered in the WiSeNts Research Roadmap [9].

Ethics is pervasive to the scenarios for cooperating objects. The participants of the workshop agreed that it should be the guiding question to ensure the social compatibility of scenarios for privacy, liability, sustainability and justice.

Below we highlight the major issues identified and provide a brief discussion on possible directions for multi-disciplinary research.

6.1. Privacy-compliant system design

The privacy issue demands minimal data collection with well defined purposes for the period of time the data is deemed necessary. Users must be informed and give explicit consent for data collection and processing under the data protection law in European countries.

At the moment, general members of the public do not seem to be concerned about privacy even with the fact that they are constantly monitored with CCTV systems literately anywhere in some European countries. Users' perception of privacy may change in the future though with higher penetration of cooperating object technologies. Users may become fully aware of the privacy issues. It is important therefore to begin discussing the issue and the solution space which spans across areas such as economics, legislation and engineering.

Studies suggest that if people get more more advantage out of a product or service they may not care about privacy. *Kubler* believes that data are negotiable economic goods and customers should receive compensation from their service providers based on levels of disclosure of private data.

In contrast, the German studies [2] conclude that there are a few legal approaches that can be used to address this issue but there is no pure solution in the legal domain. Technical solutions such as data minimisation, purpose binding of data collected and controlled identity management should be used as well.

The important message is the consensus that early adoption of privacy in the design of systems should be encouraged. Privacy should not be dealt with as an add-on function to the system with data filtering and minimisation [10]. From an economic standpoint, if privacy is not addressed at an early stage later corrections through regulatory measures can be expensive to implement.

The design, however, must not be rigid and should be adaptive to consider enforcement of new legislation. Some companies have already claimed that addressing privacy in the system design of AmI brings cost and complexity to the overall system. But the lack of compliance to the data protection legislation is a non acceptable financial risk for any company [2].

6.2. Responsibility and Liability Construction

The cooperating object technology is likely to demand further legal measures for the areas of data privacy and dependability of systems.

Legal implications largely depend on the level of autonomy of the cooperating object scenarios. Are they there to provide information to assist users in their decision making process (semi autonomous)? Or are they there to make decisions and take actions on behalf of the user? The latter is of most concern.

Full autonomy brings the issue of *transfer of control* from the users to a set of autonomous entities in the form of cooperating objects. Such a shift of control and the near impossibility of identifying responsible entities in cases of failure make any *construction of liability* an extremely difficult task. The global context with systems deployed in different countries makes the issue even harder to deal with. Law experts believe this is a roadblock for the future development and commercialisation of cooperating objects technologies.

Clear specification of functionality of systems is a key aspect here. Complexity is believed to arise from the highly pervasive and distributed nature of the system and it needs to be addressed in the design space of the cooperating objects systems. Distributed control could also raise the issue of dissipation of responsibility. The aviation industry have shown that is extremely difficult to establish responsibility for accidents that involve complex distributed computer control.

One of the approaches would be to hide from the users the inherent complexity of the system. But there is a compromise to achieve. The system itself is likely to be composed of miniaturised devices (physically invisible) and the more the functional details are hidden, the less transparent the system becomes. Lack of transparency in the processes, existing data and extracted knowledge is a major legal implication.

The functionality of cooperating objects must thus be transparent to the users and 'black boxes' designs must be avoided. Changes and the results of processes must be properly documented.

For instance, the learning algorithms of intelligent cooperating objects must be clear to their users.

However, care must be taken here. Even if the user knows about the internal system of an object (assuming the user is educated enough for this) the learning process can still result in unpredictable autonomous systems.

Transparency then becomes a broader issue. The system needs to indicate what it has identified as worth learning and propose a plan of actions to deal with unexpected circumstances (which are the ones to cause the most problems).

This seems to be a step well beyond the concern of transparency raised for data privacy and liability construction. It is only when privacy issues with respect data collection and processing are solved that the issue of transparency of machine learning systems can be fully addressed. This is a long-term issue that deserves further investigation though.

6.3. Reliability and Dependability

Cooperating objects are supposed to exist closely coupled with the environment and so will be subject to wide range of largely unpredictable inputs and changes in the context.

In light of inevitable failures of the systems one approach is for the cooperating objects to advertise their current status so that applications may adapt and continue to provide best-effort functionality in these situations. This is the concept of Dependable Systems for Sentient Computing as advocated in [1].

A dependable system can provide, at any time, a specification of current system performance and status, often associated with levels of confidence. Dependability is then the property that provides the necessary support to tell how reliable, how available and how safe the system is.

Dependable applications would analyse such results and quality measures before taking any action which can be critical as for example in healthcare where actuators perform medication and other procedures.

6.4. New Types of Human-machine Interfaces

To achieve the full vision of cooperating objects while addressing the legal issues one needs to balance the autonomy of these systems with human intervention.

On a technical and social perspective, the design of human-machine-interaction that takes into account such a balance is a major challenge. New types of user interfaces are needed to support such an interaction between humans and almost invisible autonomous objects.

Research on cooperating objects should strive to design systems and user interfaces that fulfil real users needs and expectations. *Shapiro* suggested that the research community in ubiquitous computing seem to be creating solutions for problems that either do not exist or are not useful.

The palpability concept presented by *Shapiro* relates to the usefulness of ambient intelligence systems applied to real world applications. In this framework, invisibility is complemented with visibility and automation with some form of user control. There is a balance in many of the radical concepts of ubiquitous computing application scenarios. This is likely to affect positively issues previously discussed such as liability construction.

A method for achieving palpability is to involve the user throughout the design process of systems, for instance, through ethnographic studies to fully understand the user's needs.

Ben Allouch analysed the content of brochures and websites of AmI products offered by companies including Philips, Microsoft, LG Electronics, IBM and others. The most frequent words found in this sample were connectedness, control, easiness and personal. In contrast, the least set of words that appeared was reliability, busy, freedom and interoperability.

These results do not correspond to the concerns discussed in previous sections such as reliability and privacy. The reasons for this are unclear but it could be that users do not care about these issues at the moment because of lack of understanding. Or it may be be due to the fact that these are unsolved problems and if asked companies would fail to provide a plausible technical solution to data privacy or reliability.

6.5. Roles of Government and Private Sector

The sphere of solutions to problems related to the digital divide are at political and governmental levels. Policies need be devised to confront these issues. Governments should play their role in making sure that useful future applications reach the society at large in those key areas historically addressed (at least in Europe) by governments including health care and individual's security.

Legislation, law enforcement and regulation are clearly areas that will be highly influenced by the new technology. The decision on regulating use of technology on some application scenarios could take the direction of common legislation, self-regulation or co-regulation, when government and private sectors join efforts to define policies in the field. The suitable type of regulation is highly dependent on the application context. Key areas such as health care and national security traditionally addressed by government (at least in Europe) are likely to be part of common legislation. But self-regulation might be acceptable in a market situation as already happens with other services such as Internet access.

Policies on data availability to interested and suitable parties must be addressed at the government level. On the technical level, different countries will have different data privacy policies. Some government will have control on the flow of data between small databases and others on large databases themselves. The sharing of information between systems of different countries should be addressed too. As much more information will become available to the government the question of how much is disclosed to other countries is an important issue. For instance, UK today send over fifty entries of UK passport data to the US.

The controller of information could be the government or the private sector or both. Medical records in the UK is stored and kept by the National Health System, whereas in the US this is done by insurance companies.

Acknowledgements

We thank Robert Harle, Andy Rice, Eiko Yoneki, Alastair Beresford, Frank Strajano and Jonathan Davies for taking part in an internal workshop held on the 1st September 2006 in Cambridge. This discussion led to improvements of this whitepaper. Thanks also to Pedro Marron, Daniel Minder, Maria Lijding, Laura Marie Feeney, Kay Roemer and Sebnem Baydere for many helpful comments on earlier drafts.

We would not be able to discuss the social, legal and ethical impacts of cooperating object technology without the help of the experts who attended the social workshop organised by Technical University of Berlin in early November 2006. Many thanks to all the participants of the workshop, which are listed in Appendix D.

A. Appendix A: Selected Entries from Dagstuhl Competition

SCC: Small Child Care

A contribution to the Applications Competition of the Summer School on Sensor Networks and Smart Objects, September 2005, Dagstuhl, Germany

Zinaida Benenson
zina@informatik.rwth-aachen.de
Informatik IV, RWTH Aachen, D-52056, Germany

Description:

SCC creates a smart environment around a child, enabling trusted people, e.g., parents, kindergarten staff, teachers, doctors, police, to gain information about the child and to interact with him by means of his surroundings. SCC consists of several stages, that is, it "grows" along with the child:

Stage 1: Planning
If a couple plans to have a child, a minute SCC robot is placed into the body of the prospective mother. This robot monitors the process of procreation. It analyses the hereditary features of a prospective embryo, and if something is going to go wrong (e.g., a child is going to have the Down syndrome), the SCC robot precludes the procreation by some mechanical, chemical or other means. In case a successful embryo was created, it informs the parents and the doctor of all important details.

Stage 2: Pregnancy
During the pregnancy, the SCC robot constantly monitors the development of the embryo and the well-being of the mother. It can transmit images and other important data (e.g., heart rate) to the doctor. It raises alarm if something goes wrong. E.g., it can notice that the fetus is not getting enough nutrition because of some problems with the placenta.

Stage 3: Baby
One of the most important questions which worries parents all around the world is: Why, for heaven's sake, does my baby cry *now*? Unfortunately, babies are not able to answer! In this case, SCC sensors integrated into the bed, the clothes, the diapers, the pacifier, analyze child's state and give hints to the parents (displayed anywhere in the room): the child is wet, hungry, has bellyache, etc.

SCC also continues to monitor child's development. All important things, e.g., when the child started to held his head, or turned over in the bed for the first time, are saved for later use in an SCC repository. This helps to avoid confused mumbling if the doctor asks parents for such things. Now, he can just look it up.

When the baby starts scrambling, SCC helps to keep him away from dangerous or valuable things by locking them up or blocking them when the baby is approaching, or, if a "passive defense" is not possible, by issuing an active warning to the parents. All classical dangerous things, like sockets, are equipped with appropriate sensors and actuators during the manufacture. Addtionally, the parents are able to tag any artifacts in their home using a robot which puts sensors and actuators into the right place on the artifact.

Stage 4: Small Child
When the child grows up, the amount of his interaction with the outside world also grows constantly. He now needs much more protection, e.g., if he goes by himself to the kindergarten, but he is also able to understand hints from the smart environment. E.g., traffic light gets be adjusted if the child approaches, such that the green light lasts longer, as children need more time than the adults to cross the street safely. Further examples of how things could be organized at this stage can be found in section "Scenarios".

Technical Requirements:

Integration of sensors and actuators in everything, including clothes and human body; huge advances in algorithms (e.g., analysis of hereditary information of a human cell on-the-fly by a minute sensor node); very dense, reliable and secure, communication infrastructure able to handle huge amount of traffic; everyday objects like pillows or cups should be able serve as endpoints of communication.

Scenarios:

A usual day

Without SCC: In the morning, my son tells me that he has toothache. I look into his mouth, cannot see anything. As I have a deadline at work, I ask him if it's really bad. He says it doesn't ache anymore. I bring him to the kindergarten. When I fetch him there after the work, he has wet boots and socks. He cannot remember how and when it happened. He never realized his socks were wet. In the next morning, he has a sore throat and toothache! Thus I have to go to the dentist with him, and then we stay at home to cure his sore throat, which he most probably got because of his wet socks. To meet my deadline at work in this situation, I have to work at night.

With SCC: In the morning, my son tells me that he has toothache. I ask his sweater to localize the pain. The sweater says there is a small hole in one of the teeth. I make an appointment at dentist for this evening. During the day, my son runs into long grass and his boots and socks get wet. The boots and the socks determine how wet they are. If just a bit, they heat themselves up a bit, and dry. My son notices nothing about this. If they are beyond self-drying, they send a message to the toy he is playing with, and the toy says him he has to change. If he does not react, the message goes to the kindergarten staff. If they do not react, it reaches me at work, and I finally speak to him (using the spoon he is now holding as a connecting device).

An unusual day

Without SCC: This afternoon I plan to go out into another town to meet a friend. We have not seen each other for ages! And I'm very lucky, because my father agreed to look after my. At 10 p.m., when I get home, I find my flat empty, and note on the floor says: "We are in the hospital". I rush to the hospital. I first spend about one hour seeking after my son and my father. When I finally find them, I discover that, blessedly, nothing is wrong. My son said to his grandpa in the evening that he has a most terrible headache. The grandpa got himself worked up frightfully. He couldn't reach me because I forgot my mobile phone at work. Thus, he called the ambulance! As soon as my son saw the ambulance, his headache was gone. Nevertheless, we had to spend the whole night in the hospital, without sleeping.

With SCC: When I'm having coffee with my friend, my cup starts to tune one of my favorite songs: somebody wants to talk to me. The SCC system found me because all my clothes are equipped with my communication address. I just have to apply a gadget to all new clothes I buy to get the address tag into them. My father tells me about my son's headaches. I query the SCC system, and my son's clothes report to me that nothing is wrong, but he seems to be tired. I ask my saucer to show him to me. He also can see me on his pillow. We speak for a while, he calms down and is able to sleep. I monitor his sleep from time to time, and query the SCC for his well-being. Everything is in order.

Benefits:

SCC assists parents, and also prospective parents, in the challenging and demanding task of raising a child. It helps to take care of *physical* well-being of children, enabling parents to spend the precious time and other resources on the *real human interaction with children*, which is crucial for child development: playing together, talking to each other, telling stories. It also saves parents lots of trouble and time, enabling them to concentrate on the work better, and to do other things which are important to them.

Risks:

Especially inserting sensors, actuators and robots into the body of a prospective mother can have scary consequences. But it also should be impossible to influence child's sex and other features by means of this technology. Besides, such an application should not *replace* the parents.

Proposal for the application competition

Sensor Pearls

Name: Matthias Gauger
Affiliation: Institute of Parallel and Distributed Systems, University of Stuttgart
Address: Universitätsstr. 38, D-70569 Stuttgart, Germany
Phone: +49 711 7816 295
Email: Matthias.Gauger@informatik.uni-stuttgart.de

General concept

I anticipate the development of a new type of sensor node, the so called sensor pearls. Sensor pearls are extremely small sensor nodes enclosed in a spherical, watertight packaging. The idea is to be able to throw a bunch of such sensor pearls into the water and let them move with the current of the water. An extremely small form factor is important for sensor pearls to allow them move freely like water molecules with only minimal susceptibility to getting caught at obstacles.

The sensor pearls should be able to collect, store and communicate different types of sensor data, including *location information*, *water temperature*, *water quality*, *stream velocity*, *water depth*, and *sound*. They should also have appropriate communication capabilities to coordinate among each other as well as communicate sensor data to interested base stations. Energy harvesting (i.e. using the water movement) could be used to collect energy for the operation of the nodes.

Motivation application scenario: Automatic monitoring and maintenance of large scale sewer systems

Problem description:

- Hundreds of kilometers of aging sewer pipes in the underground of large and small cities worldwide.
- Controlling the condition of the pipes is a time-consuming and expensive task
- Working in underground sewer systems is probably one of the hardest and least pleasant jobs available.
- Undetected leakages pollute the environment over potentially large periods of time.

Solution approach:

The idea is to have large parts of the monitoring and maintenance of sewer systems done automatically with the help of sensor networks and actuator nodes.

Sensor pearls can be used to monitor the complete sewer system of a city. Deploying them should be as easy as throwing them into a water drain at the desired location. The sensor pearls then flow with the stream of water in the pipes collecting data on their way.

Potential damages or problems can be detected with the help of the following sensing operations:

- Using location information to detect sensor pearls leaving the expected route of the pipes (through a leakage)
- Detecting maelstroms by comparing the movement of a set of sensor pearls
- Detecting suspicious sounds that might indicate leaks
- Monitoring the speed of movement to detect emerging plugging of a pipe
- Detecting changes in the depth level

The sensor pearls could be complemented by additional sensing and actuation devices:

- At critical points of the system, stationary sensor nodes can provide constant surveillance of the system's overall condition. Beneath doing measurements they could also help during the localization of the sensor pearls.
- Concepts used in structural health monitoring with sensor networks may be also applied for checking the condition of pipes or channels.
- Mobile robots can be used for visual inspection of suspicious pipe parts to verify whether there is a damage that needs to be repaired. It should also be possible to repair smaller damages without the need to dig up the pipes. Although some robot technology is already being used nowadays for the inspection of sewer pipes, they still need to be operated manually. In the future I expect the visual inspection as well as small repairs to be done autonomously.
- If manual intervention or a large repair by workers becomes necessary, a display could be used that communicates with the sensors and visualizes the condition of the pipes at the current position of the maintenance workers.
- All sensors can generate warnings if the air quality is dangerous for the workers.

Benefits:

- More complete and at the same time less labor intensive monitoring of systems
- Faster detection of leaks and pollutions – less negative impact on the environment
- Less burden on the human workers
- Cost savings by autonomous monitoring and repairing / Less costly repairs due to an early detection of damages

Additional application fields

- Sensor pearls could help scientists to investigate flows of water in rivers or oceans. It might even be possible to follow subterranean water flows (which is nowadays being done using colored water). Self localizing sensor pearls might provide much more detailed information and could, for example, help digging water wells at promising locations.
- Monitoring water quality and localizing potential polluters
- Detection of chemical contamination in fresh water pipes or swimming pools
- Flood warning system

Technological challenges

- Sensor node communication: Propagation characteristics in the water or at the surface differ from standard wireless communication. Additional challenge: Wireless communication characteristics in closed water pipes.
- Extremely small form factor of the water pearls
- Spontaneous self-organization of a "flow" of sensor pearls
- Energy harvesting technology for the sensor pearls
- Integration of the large variety of desired sensing technology

Extending the vision further

Controlling whether the water pearls swim on the surface or at a certain level below surface might be important to allow sensor pearls to follow water streams in different kinds of situations. So it might be necessary to equip the pearls with actuation technology that allows it to control its depth like a submarine does. It might also be helpful for the pearls to be able to keep their position for a certain amount of time or to even move upstream.

Muneeb Ali
LUMS
muneeb@lums.edu.pk

A humane world where people can live in security and dignity, free from terrorist bombings and biological weapon attacks etc, is still a dream and should be enjoyed by all. In such a world, everyone would be guaranteed freedom from fear with an equal opportunity to fully develop his or her human potential. In essence, human security means freedom from pervasive threats to people's rights, their safety or even their lives. Human security has become both a new measurement of global security and a new agenda for global action. Human security and human development are two sides of the same coin, mutually reinforcing and leading to a conductive environment for each other.

Imagine a world, in which when two teens, armed to teeth, are about to enter a high school, the weapons are instantly detected by sensor networks deployed all over the city and they send warnings to the police and also to everyone inside the school that "some weapons are about to enter high school premises!!"

Imagine, that you are walking late at night towards your home and you are aware of all the potential "active" weapons like guns, knives, and baseball bats present on different paths to home. Such information could enable you to select the safest route home.

Let us take things from the personnel scale to the global one Let us take things from a personal scale to a global one, one with a war on terrorism and let us not get into the debate of right and wrong. Let us just view things as a third person. Now imagine a world where no terrorist activity is possible because the security checks are not merely at the airports or only when someone gets on a bus or train but the security checks are omnipresent in a transparent way – integrated into the physical world itself in the form of ubiquitous wireless sensor networks. These millions of wireless sensors detect objects that could potentially be used in terrorist activities e.g. they can detect anthrax, gun powder, guns, bombs etc and they can pin point the exact location of such objects and the persons carrying them.

If we take USA as an example, maybe we cannot disarm the around 200 million firearms present in the country as the Third Amendment states “every man has the right to bear arms” but maybe using the ‘human security network’ powered by sensor networks we can give every man the right to know how many and what kind of arms are present in his current surroundings, in order to let him decide if he/she is at threat, so that he or she could take respective security actions in light of this information.

On the flip side of the coin, by having a safer world to live in the tensions between citizens of different countries or races could be reduced opening up equal opportunities for human development. No longer would creed or color be a discriminating factor, hindering global and individual progress and development.

Students would no longer be rejected study visas on the basis of their country of origin. People would not have to go through the humiliation of invasive searches at airports. Based on prior information about weapons, people would feel more comfortable when talking or interacting with strangers.

A lot of technological and social issues would need to be resolved before such a human security network could become part of our daily lives. The biggest social issue to resolve would be privacy – to what extent could we invade everyone’s life to make this world a safer place?

Smarter utilities

Despite all concerns regarding energy usage, waste and conservation, etc., the user never pays the real price of what is being consumed and all too often there is little incentive to do so. Why should the cost of metered tap water for drinking be the same as that sprayed over a lawn? Why canít a householder be charged for electricity on a device by device basis and possibly being ërewardedí with cheaper electricity for having invested in an energy efficient device? The main reason is that the utilities cannot differentiate. With low cost wireless sensors built into taps, lights, switches, heating systems and appliances there is the potential for the utilities to provide itemised billing and a whole host of value added services, well-being monitoring, remote monitoring, remote control ñ and that might even allow the utilities to remotely enable/disable selected devices for whatever reason.

Paul Bowman

Large scale deployment of heterogeneous sensor networks using animal implants

Originator

Kasper Hallenborg, Maersk McKinney Moller Institute, University of Southern Denmark, Campusvej 55, DK-5230 Odense M, Denmark
Email: hallenborg@mip.sdu.dk
Phone: +45 65503585
Fax: +45 66157697

Introduction

Every year thousands or even millions of animals are being tagged or marked, not only to identify farm animals, but also for the purpose of monitoring habits of living for birds, fish, whales, reptiles, etc.
They provide a distribution platform for sensor nodes. Instead of RFID implants or even simple metal leg bands the animals could be tagged with advanced sensor nodes. Progressively the distribution of sensors will be global and ubiquitous, and provide a complex network for data mining and environmental monitoring.

Description of system

Imagine a world where we are able to monitor and combine information of the environment, the weather conditions, pollution, etc., with the health conditions of living species. Fighting the social resistance against having sensor node implants injected into humans at birth might be even harder than crossing the technological barriers, therefore a similar “platform” should be used.
Having animals, e.g. birds, tagged with small traditional sensor boards wouldn’t bring much information that cannot already be gathered by satellites or ground-level sensors. Thus, the new advanced sensor nodes should be a combination of sensors for environmental monitoring and BioMEMS for monitoring the (health-)condition of the animal.
The randomness in distribution and the number of nodes will be challenging for the reliability and dependability of the network. Also regarding the abstraction and reporting of data for central processing and data mining will challenge the work with such heterogeneous sensor nodes. Nodes must be adaptive to calibrate themselves towards normal conditions for the animal and may only report signification changes relative to those conditions. By this means the sensors nodes can report not only dynamic environmental information, but also information about the influence on health conditions.

Technical requirements

Obviously, size will be a key issue for such nodes, maybe not for whales, but marking birds should not influence their capabilities or behavior. Health-condition sensors might be implants embedded into the tissue and/or blood pipes of the animal. The concentration of various chemicals and bacteria/viruses could be measured using microscopic cantilever-based BioMEMS, which constantly are in touch with the blood flow, so

injection samples do not have to be taken all the time and eventually drain the animal for blood.
The second import issue is power. Even decades from now is it not realistic to believe that power consumption can be ignored and tiny batteries will outlast the life of an animal, and weaving solar-cells into the wings of birds might be further away. Thus, the nodes should be powered by small kinetic energy cells recharged by the motions of the animal. Samples could be taken whenever enough energy has been stored in the cell and the data will be pre-processes and transmitted wirelessly either to geo-stationary satellites or ground stations. Larger animals could also act as mobile gateways with temporary storage collecting and forwarding data from smaller animals. Surely, the kinetic energy source would not apply for all animals, such as mussels moving only a few inches during their entire life (~15 years), but then small flywheels or likewise could be applied.
Besides the internal body sensors an extensive set of traditional sensors should be attached for localization (GPS), environmental conditions, etc., and even small cameras should fit some platforms.

Scenarios

Birds travel long distances at different times of the year, but also in their daily search for food, thus they are ideal carriers of sensors to spy environmental changes both over land and over sea. Using cameras they could be used to spot oil releases from coasters in the ocean and report to services organizations taking care of the release at an early stage.
Changes in blood concentrations could be related to air pollutions in big cities and give estimates of the effects. The spreading of diseases carried by animal could be monitored and warn people in advance, eventually by reprogramming the sensor nodes to recognize new diseases like the bird flu, when they are first discovered.

Benefits

The key benefit for the system is the natural and random spreading of sensors globally. Combined with the option of relating environmental conditions to both short-term and long-term health conditions across species gives a unique opportunity to estimate health problems for human without actually monitoring humans, as humans are more likely to change their behavior, if they know that they are being monitored, than animals are.
Some animals tend to move in flocks, which gives a reliable mobile node of aggregated data.

Risks

There are two obvious risks in such a system, first that the sensor nodes cannot be created small and lightweight enough not to influence the behavior of the animal. Secondly, to secure a reliable distribution of the sensor nodes in the environment, as some animals tend not to be in the same living areas as humans, but on the other hand changes in these patterns could be valuable information for forecasting human health conditions as well.
With every monitoring system there is a risk of people relying too much on the information and tend to disregard other information, thus this system should only be thought of as a valuable supplement to existing individual health examinations and environmental monitoring.

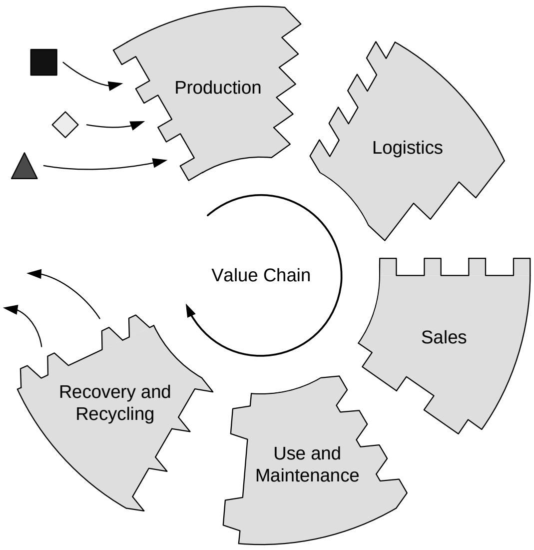
Smart Labels for Enhancing Value Chains

Contact information

Clemens Holzmann
Department of Pervasive Computing, Johannes Kepler University Linz, Austria
Mail: clemens.holzmann@jku.at; mobile: +43 650 2215315; work: +43 732 2468 1226

Description from user perspective

The basic idea is to make value chains – including production and inbound logistics, outbound logistics, sales and marketing, as well as maintenance and recovery (see figure) – smarter by using smart labels, and particularly to overcome incompatibilities at the transitions from one phase to the other (denoted by the different tines in the figure). In a 10-20 year timeframe, I think we can expect such labels including sensors for acquiring information about their environment, together with processing- and wireless communication-capabilities attached to even the smallest products or parts of them, as it has already become possible with passive RFID labels by now. By doing so, every product and even each part of a product which is to be manufactured, has a kind of intelligence, which can significantly enhance the whole value chain and make manufacturing more flexible. The products have information about the environment, can describe themselves (their properties, history etc.) to others wirelessly and know what they intend to do next.



First, inbound and outbound logistics can be facilitated, as the parts themselves know how they want to be stored (e.g. at which temperature), how they want to be processed (e.g. what colour they want to have) and what they want to do next (e.g. put together with another parts or processing at another machine).

Second, the routing of parts throughout the manufacturing halls can be made more flexible and scalable; each part or product knows where it wants to go next, and just takes a transport vehicle (which means that it asks a transport vehicle in proximity to stop and carry it to a certain machine). There is no central control which has to know each part and the respective treatments as well as the current state of the whole production process. In contrast, all the objects are autonomous and "know what they want" – including how they want to be recycled. This is for example a significant advantage in the case that the manufacturing process is interrupted due to a failure, as the system does not need to remember a certain state in order to continue at this point; instead, the whole process organises itself.

Moreover, the products know their whole history, which is useful not only in the manufacturing process and in logistics, but also when storing, selling and recycling them. For example, they remember where they have been produced and sold, how old they are and if there have been some accidents (e.g. hard drops on the floor).

Technical requirements and open issues

MEMS-/nanotechnology-based sensors and processor platforms, which can be embedded in flexible labels at low cost, are required.

A serious problem is power supply; if passive labels without power supply are used, the power must be induced by special readers (as it is the case with passive RFID technology). In manufacturing, this job can be done by carriers for example. Another approach is the use of accumulators, which are recharged by kinetic or solar energy for example.

Another issue which has to be solved is security. More precisely, the information provided by the smart labels as well as their goals must be trustworthy and needn't be malicious or accidentally wrong, respectively.

Scenarios

Let us have a look at a car manufacturer. All kinds of parts of which a car is composed of, arrive in the manufacturing hall. They are identified by their self-descriptions, and automatically updated with certain intentions (namely to be a certain part of a particular car) as soon as they arrive (how they should be processed, for which car they should be used etc.).

Afterwards, they go through the whole manufacturing process as mentioned above, namely by telling the machines how they want to be processed and where they want to go next. Inbound and outbound logistics do not need a central coordinator, as the products organise themselves (e.g. they negotiate about where in the storage they want to be placed, depending on which other products with which time constraints are already in there).

As they provide a detailed self-description, they can enhance advertisements and storage in shops also. And, finally, if this smart product has to be recycled, it provides detailed information about how it has to be recycled for example.

The Supportive Road

Patrik Spieß,
SAP Research,
Vincenz-Prießnitz-Str. 1
76131 Karlsruhe, Germany
patrik.spiess@sap.com,
Phone +49/721/6902-67
Fax +49/6227/78-44398

Description from a user perspective

- Mr. R is an employee of the City of Berlin. During the winter, it is his and his colleagues' responsibility to apply salt onto the roads to melt ice and thereby ensure traffic safety. Not so long ago, he would regularly follow a fixed route and release a constant stream of salt off his truck, but since the roads are now equipped with maintenance-free wireless sensors, that harvest energy from the pressure of passing vehicles, the city saves a lot of money although his job did not get any more difficult. He only goes out if the monitoring station in the control centre indicates that there is danger of ice on the roads – this typically happens in the early morning of chilly nights. Prior to departure, the system calculates a detailed route and transfers it to his truck's navigation system. The route leads him to all spots that are likely to have ice on them rather than just driving through each road. Along the road, Mr. R. does not have to bother about how much salt should be cast at which point of the road. The sensor nodes in the truck pick up the information of the sensor nodes in the road and put the optimal amount of salt onto the road. This significantly helps precious inner-city trees that are already exposed to significant stress like air pollution.
- Ms. B is a senior manager of a mid-sized company. She is on the road almost every day, rushing from one appointment to the next one. The multi-billion program of the German government aiming at putting sensor nodes into the major roads of Germany saves her a lot of money and stress.
  For the time being, traffic jams have become a rather rare phenomenon. Future growth in car density may lead to new problems, but the technology clearly relaxed the situation a lot. For the first time in history, traffic engineers have access to fine-grained, near real-time road occupancy data. A huge, distributed computing system collects all this data and calculates route suggestions on the level of single cars.
  Ms. B was one of the first people who had a mobility agent installed in their car. Of cause, the technology is still expensive, but economies of scale will lower the price of the hardware and the ongoing price war of 4G wireless bandwidth providers made transmission of route advises very cheap. As more and more mobility agents are built into cars, more and more drivers follow their recommendations. The system has become a powerful means of preventing congestions.
  For all the other people on the road, more coarse-grained directions are given, such as changing traffic sings that show expected travel time for a given road segment ahead.
- Mr. T really objects the new technology that is applied to more and more roads. He is afraid that all his trips could be tracked and archived for an indefinite time. From a certain perspective, he is right. The system actually assigns each car that has a mobility agent on board to a virtual car in the model that represents the traffic. However, for this association, not the unique identifier of the mobility agent is used, but a random session identifier like it was done back in the old GSM system. Of course, the association between temporary and permanent ID could be matched if both were stored, but the government has put tight restrictions for that, requiring a court order and a the threat of a capital crime for the tracking to be done. From an objective perspective, Mr. T's attitude is understandable but mostly irrational.
- Ms. L is a road technician working for a major road construction company located in Bremen. She is only partially happy with the new system of self-organizing roads. Of cause, during the big deployment phase, her company really soared, since it equipped half of Lower Saxony's roads with sensors. But soon after that, regular inspection of roads is no longer carried out. The company does not get as many work orders as in the past sensor era. The sensors that have been put into roads do a good job in determining flaws in the road structure.
  Once such an irregularity has been detected, a backend system switches the sensors on site to

extensive monitoring mode and takes a "closer look" at the data coming from the spot. If, after a certain time, the values indicate a problem, an inspection team is sent to the specific area.

- Mr. F is truly in favour of the new sensor technology. The system warned him about a congestion that ended right after the tip of a hill. He was running at 160 kilometres per hour and had he not been warned by his mobility agent, a serious accident could have occurred. The sensors ahead recognized the movement pattern of congestion and routed this information two kilometres backward the road by geocast. The sensor node in Mr. F's car received the warning message and immediately forwarded it to the mobility agent, which projected a warning image onto the windscreen and used the car's sound system to tell the driver to break.

Technical requirements

- (Major) **roads** are **equipped with sensor nodes**. They are deployed in each lane at a distance of 10-50 meters.
- **Base stations** every 1-5 km pick up the measurements routed to them.
- A **high-bandwidth backbone** network should be able to transfer most of the data produced. Although local processing is preferable, backend-only processing must still be possible.
- **Sensors**
    - The sensor nodes need to be equipped at least with a **vehicle-passing detector**. From the time / pressure pattern, they could also infer vehicle class (truck, passenger car, van ...) and approximate speed.
    - **Temperature** sensors help supporting countermeasures against ice.
    - **Material integrity** sensors allow for inspection if required, as opposed to on regular schedule.
- **Geocast Routing Protocols** that allow sending messages to groups of nodes like "n meters back / forward".
- **Energy** is harvested by using the force that passing vehicles exert on the road.
- **Privacy enforcement** methods are applied to assure driver privacy for private drivers. They are enforced by legal regulation and external supervision.
- **Mobility agents** in cars are given detailed route information via a wireless downlink. On the uplink, they inform the backend about driver intentions. In most cases, the mobile agent knows the destination that the driver wants to reach, either by identification of regular patters (every morning, driver X drives to her workplace, in the evening to her home and on the weekends to the shopping mall) or because the driver specified the destination because he wants to be guided by the system. The mobility can even tell the system about the driving style of a driver (aggressive, defensive, ...) which might optimize
- A **ubiquitous, wireless network** (3G, 4G) to enable communication between backend and mobility agents.

Scenarios and Benefits

See Mr. R, Ms. B, Ms. L, Mr. F

Risks

See Mr. T

A Sensor Network for our Brain

Urs Bischoff, Lancaster University, Computing Department, Infolab21,Lancaster University, Lancaster LA1 4WA, UK, u.bischoff@lancaster.ac.uk, +44 (0) 1524 510367

Introduction

Our brain is most probably one of the most important parts of our body. It controls all vital functions. Our brain receives signals from different parts of our body through nerves. These signals are processesed and reactions are triggered based on prior experience and physical needs. The brain consists of billions of neurons. The neurons carry information in the form of electrical pulses. They communicate with other neurons in the brain and throughout the body by sending various chemicals across the synapses. The whole system is very complex. But what happens if we could better influence the storage of information and the communication in our brain. Would it be possible to influence our brain without relying on our basic sensory system (e.g. Eyes, ears etc.)? Is the human-computer interface dependent on our sensory perception? All these questions would be answered in different ways, if we could implant sensor nodes in our brain, which can communicate with both external systems and the neurons.

Description from a user perspective

In our daily live our brain plays a major role. It is responsible for pain, hunger, fatigue etc. Furthermore, a lot of problems are caused by dying parts of our brains: e.g. Alzheimer's disease or Parkinson's disease. Learning and recalling of information play major roles for daily activities. Everyone sometimes wants to have more influence influence on all these functions. Who hasn't sometimes wished to just inject a new language in their brain? Or who doesn't want to turn off pain caused by an accident? Or, what about turning on the lights by just thinking about it? Or how nice would it sometimes be to communicate with someone without even talking to the person? If sensor nodes could talk the "brain"-language and if they could identify the correct neurons, this wishful thinking could become reality. As a user I just have to eat food enriched with very small sensor nodes. Then, they automatically find their way to the essential parts of the brain.

Technical Requirements

These sensor nodes have to be very small, i.e. smaller than the size of bloodcells so that they can enter the blood system. It might be necessary to have millions or billions of these sensor nodes in our brain. Instead if intaking them through food, it could be possible to inject them to the brain. However, a small form factor is essential. Energy consumption also plays an important role; it should be possible to use the available energy in the brain. Furthermore, they have to be capable of storing, acquring or synthesising neurotransmitters. The material also have to be compatible with our body cells. In order to interact with the brain they have to "speak the language of the neurons". Wireless communication is necessary to exchange information with the outside world. The idea is very visionary. However, first steps have been done in this direction. Brain implants have been successfully used to circumvent areas in the brain, which became disfunctional after a head injury. These implants stimulate single neurons or group of neurons in the brain. Eye implants in combination with brain implants have been used to restore basic visual functions of patients. Another area of reference is called deep brain stimuation. Implanted devices are used to send electrical impulses to certain areas of the brain. It is successfully used to treat slow body movement assiciated with Parkinson's disease.

Scenarios

Two simple scenarios are described. One is more realistic, the other one is very visionary.

Scenario 1

Bob is a 9 year old boy who likes to play in the garden. As most boys at his age, he likes to climb on trees or play with fire. These activities can be quite dangerous sometimes. On a Sunday morning he wanted to steal some cherries from the neighbour's tree. Because he didn't want to be caught, he got up very early. Unfortunately, the nicest cherry were on a very thin branch. His desire was stronger than his reason. He fell and hurt his knees. He ran back to his parent's bedroom who were a bit annoyed because they were still asleep. His mum saw that there were only some scratches on his knees; there wasn't any major problem. So she decided to use their first-help handheld device. She pointed the device to Bob's head and just turned off his pain. Everyone was happy again.

Scenario 2

Sarah likes to travel. Especially exotic countries in the Southern hemisphere are at the top of her wish list. Unfortunately, they don't normally speak English there. This summer she wants to travel to Tanzania where they speak Hadza. She doesn't know anyone who could teach her this language. So she decided to go to a shop and buy this language on form of a sensor network. Because she only needs a basic knowledge, it was enough to buy a can of a vanilla drink that contained all the important words and grammar. She drank it in the evening; and the next day she was able to speak basic Hadza.

Benefits

It could be the solution for a lot of brain related diseased. Damaged areas in the brain could just be supported by the sensor node. The neurons are expected to be necessary because sensor nodes can only take over certain functionalities. It could also give new forms of communication with machines. The brain-computer interface without motor output from the user could be improved (first prototypes already exist). Communcation with other people could be improved because of two main reasons: (1) the language barrier could be decreased because people can easily learn new languages, and (2) direct communication between our brains could give us a better understanding of our peers.

Risks

There are medical, social and ethical problems that could be caused by this kind of technology. Only a few potential problems are mentioned here. In Scenario 1 a medial problem was addressed. We know that pain is essential; it gives us important information about parts of our body. If we didn't feel pain, some parts of our body could get destroyed and we wouldn't recognise it. Is everyone allowed to “eat” a new language? If not everyone can afford a new language, it could increase the social gap between rich and poor people. Other problems include security and privacy: How can we make sure that someone else can't influence our brain in a bad way. Of course, these artificial nodes could cause infections or other complications in our body. All these risks show that this idea is very visionary. There is a deep gap between the obvious advantages and the huge risks.

Body area sensor network for small children

Originator

Timo Vuorela
Tampere University of Technology / Institute of Electronics
Korkeakoulunkatu 3 33720 Tampere Finland
timo.vuorela@tut.fi
Tel. Work +358 3 3115 5350
GSM +358 40 537 6030

Description

This is an idea of body area sensor network targeted especially for small children. Every node in the network contains a temperature and a humidity sensor, which make it possible for parents to monitor child's skin temperature and to see if the child is sweating. This sensor network is mainly targeted for very small children who are not able to tell whether they are feeling thermally comfort. As a user interface for a system there could be for example a cell phone containing one sensor node, which would act as a sink in the network.

There are commercial temperature sensors available, which are targeted for measuring the temperature inside child's clothing. Usually these sensors measure temperature only from one point, e.g. in the neck, which does not give a good estimation of child's overall temperature. A sensor network would be a big improvement because it could produce data from many different points around child's body.

Technical requirements

Sensor nodes should be cheap enough so that it would be possible to add few nodes permanently to every piece of small children underwear. If an underwear shirt contains e.g. four to six sensor nodes the total cost of these sensors should be less than two euros. Further more sensor nodes have to be washable. If sensors must be removed every time the underwear is washed then the system is too complex to use.

In order to make the network unnoticeable the size of sensor nodes should be as small as possible. An ideal solution would be to make nodes so thin that they are elastic. However, the structure of nodes should be very durable because the environment inside clothing is very harsh. Usually temperature is around 37°C but humidity can be very high. Furthermore sensors are to be exposed to different kind of impacts while child is moving.

Power consumption forms a problem because it is not desirable to change batteries to every sensor node even if the replace cycle is relatively long. Furthermore, batteries could easily be larger in size than the nodes itself. One solution could be to use super capacitors, which are charged wirelessly before the clothes are put on. For example there could be a system in the clothes closet, which charges the capacitors of the sensor network when clothes are taken from the closet. The power consumption of the network can be kept relatively low because the temperature and humidity are values, which do not change rapidly. Therefore, sampling rate can be low, which reduces the usage of radio circuits. Also the distance between the sensor network nodes in this application is quite short, which makes it possible to utilise low transmitting power.

Scenarios

New parents are many times unsure when clothing small children. Especially in northern countries it is sometimes difficult to estimate how must clothes a small child needs in the wintertime. Therefore parents many times add one extra layer of clothes just to make sure that child is not getting cold. If there were a sensor network integrated into a child's underwear then it would be possible to measure the child's skin temperature and to adjust the amount of clothes according to measurement results. If the sensor nodes contain a humidity measurement it would be also possible to detect if child is sweating.

Once the sensor network is utilized to clothes it would be easy to add new applications to it. A traditional application could be e.g. a shirt, which can tell to washing machine the correct washing temperature.

Benefits

This kind of body area network could be also implemented with wired sensors, but in clothing wires are always an additional source of weight. Especially in children clothes it is important to make network as robust and unnoticeable as possible. One way to decrease the weight of wired network is to replace normal wires with conductive fibres. However conductive fibres are not very robust and the insulation of these fibres presents a problem. Furthermore long wires are a risk because if there are not properly attached their can get around child's neck. According to these facts a wireless sensor network is a very good solutions to this problem as long as nodes are small and energy consumption reasonably low.

Temperature measurement application would make a life little bit easier for new parents who are not yet learned how to estimate the amount of clothes the child needs.

Risks

Parents of the small children could be terrified about the idea that their child is wearing a cloth, which contains many sources of electromagnetic radiation. If the sensor nodes are very small they must be attached to the clothing so firmly that small children cannot tear them apart and eat.

A relay backbone network inside telephone equipment for time-critical data forwarding and audio processing

Paolo Casari

University of Padova – Via G. Gradenigo 6/B, I-35131 Padova (PD), Italy
E-mail: casarip@dei.unipd.it, Phone: +39 049 827 7753, Fax: +39 049 827 7749

Description from a user perspective

In the future, voice will be commonly conveyed from place to place in diverse ways, so that at least three diverse transport kinds are recognizable nowadays: the first two are represented by the already widespread cable networks (e.g., PSTN) and by mobile cell phones, whose cellular networks are known to cover whole nation-wide extensions. The third kind will most probably be represented by VoIP technologies, whose use is penetrating faster and faster into people's habits, mainly due to its low costs, its comparably good reliability and the good functioning of common VoIP applications, like the well-known Skype®.

If many people all over the world use many methods to transfer voice, by direct consequence a lot of terminals are deployed over the territory, no matter what technology they rely on. This fact offers an unprecedented opportunity to construct a widespread backbone sensor network that could be used to forward time-critical messages to the appropriate data collection stations.

Inside any new built and sold telephone terminal, would it be PSTN, cellular, VoIP or anything else, a single, tiny sensor could be installed (two or more sensors may provide redundancy, but this is excess detail). This sensor is never to be accessed by the user, as it will provide no new services, but will instead connect to as many other similar sensors as it senses inside its coverage range, so as to form a very large, maybe metropolitan or greater, wireless backbone network.

Of course a backbone network has a lot of possible uses, but since this will not be accessible by typical customers, its uses will be limited to the applications that really need it. The network could be imagined as somehow belonging to the local or State administration, from a legal point of view, so that its use could be reserved to the administration itself or given in concession to companies providing time-critical services for a fee, as imagined in the "Scenarios" section.

The "sensing" feature is to be provided by audio sensors. In the future, a higher and higher processing capability is expected to be available in single nodes, so that, for instance, they could "extrapolate" key words from sensed voice and decide whether the speaking person is to be considered dangerous or not. This could be of great help in those scenarios where a Public Security team has to intercept phone calls made by controlled suspects, as the audio sensors inside telephone equipment could be configured to simply forward the whole audio call to a receiving station or, for instance, to process voice locally, recognize some selected patterns and report them back. Of course, this is a great invasion into people's privacy, but as already said, only the properly authorized entities are to be allowed to use this system feature. Any other user shall simply see a backbone network. Moreover, it is nowadays a common procedure to intercept those calls made by suspected criminals: the envisioned system would simply provide this capability automatically and at a very low cost, without having to mine data from telephone companies' databases.

Technical requirements

The network is expected to be very dense in (and near to) inhabited conglomerates. This means that nodes may operate at very low duty cycles without tampering connectivity. This also means that nodes can afford low transmission powers, enabling longer lifetimes, not to say that in very critical situations they could draw energy from the terminal they are installed on. The network may anyway be sparse in zones between towns or cities. If really necessary, eventual connectivity holes could be bridged by boundary high-power radio relay stations. A geographic routing or dissemination protocol should be implemented, in order not to bother uninterested network portions.

As the network serves to convey critical or very private data, security is of utmost importance. Proper cautions should be taken to avoid data interception and/or modification, jamming, or sensor triggering by unauthorized entities.

Finally, advanced audio processing capabilities and multi-language pattern recognition is required to perform speech analysis on demand.

Scenarios

Local administration could use the network to forward alarms to the appropriate handlers, (e.g., fire detections to firefighters, air conditioning faults to maintenance, etc.) without having to install dedicated networks. Private companies winning an auction and gaining a concession could sell the same service to customers, and run it on the same, already deployed network.

Health-related services may be set up where an ill person is present (why not, with sensors to track and follow essential life signs). These sensor could send information to a health care center through the backbone network, starting from a nearby phone equipment.

People could be kept informed of what is happening at their place while they are not at home, by means of intrusion detectors sending data through the backbone network up to a user terminal.

Magistrates could allow some Security Forces to intercept phone calls (no matter the used technology), and this operation could be set up in virtually no time.

Benefits

The described sensor network is very easy to build up, considering that phones are everywhere and that they undergo a relatively fast replacement, in particular cell phones.

A dense, reliable backbone offers the opportunity to support many time-critical services, along with the considerable advantage that sensor batteries allow to keep them up and running in case of somehow destructive environmental events (for example, a storm that cuts some power and telephone cables).

Furthermore, new services that are endowed the right to use the network may be deployed in a very easy and fast fashion, as the only thing to set up and ensure is radio backbone access, i.e., the presence of phones nearby, which is an easy requirement to meet.

Risks

As in any sensor network, some nodes may eventually die out due to battery exhausting, and connectivity holes may arise as a consequence, or even worse, the network may become disconnected. In the first case, it is supposed that routing around holes can be performed in some way; the second case is instead more difficult to handle and should be avoided, for instance by ensuring that phones are replaced with high probability before the battery dies. This would require some statistical consideration that may be not trivial, as it could happen to depend on the local network utilization, node density, number of deployed services, different QoS requirements and so on.

An already mentioned risk is security, as no unauthorized person is to be allowed to use the network, and data are to be protected from any intrusion or jamming attempt.

Supermarket of 2015

Dikaios Papadogkonas,
email: dikaios@dcs.bbk.ac.uk
phone: 020 7763 2122
Computer Science and Information Systems, Birkbeck College, University of London
23-29 Emerald Str.
LONDON WC1N 3QS

User Perspective

Supermarkets are big corporation, with some of them having large superstores that sell almost everything you might need, from toothpaste to 40 inch flat televisions. On the other hand because of the big competition between similar products that are sold from the same market, producers tend to make now and then special offers, or better the quality of their products in order to attract more consumers. In such superstores a user can get confused, miss the offers he might liked or buy staff that he could find in better prices.

The supermarket of 2015 and each object will be aware of its context. It will know the expiry date, the quantity, the quality and every other specification that defines the product. The basket will be able to consult the shelves in order to check whether the content of the basket is the best the user can get and in case there are better offers it will be able to suggest buying a different product instead of the one the user putted in the basket. The basket will also tell the user the cost of the products that he is going to buy so that he will not have to wait in line. The supermarket of 2015 will be even aware of its own customers and it will know what the user mostly likes to buy, in cases of new products it will automatically notify them and it will suggest products that customers with similar prefers buy and he might be interested in. The objects will be smart enough so that they will notify the managers for expired products that are currently on the shelves and the shelves will calculate the quantity of each product and automatically update the market's database.

Technical Requirements

The supermarket needs to be aware of who gets inside. In ten years I assume that all mobile phones will have Bluetooth. So the supermarket entrances and cashiers enquires for Bluetooth devices and the MAC addresses never entered the shop before are stored in a database with information of what the user shopped.

All products are currently tagged with a bar code. In ten years time every product will have attached an RFID tag that will store the information about the products, on the products rather than in a database. This way the shelves which are going to be equipped with a network of RFID readers, will be able to read the data and update the supermarkets database of what is currently in stock. It will also have a Bluetooth module that will transmit information to the basket.

The basket will have a small PDA type machine attached that will query via Bluetooth the shelves or the "supermarket" and get the information to be presented to the user. When the user goes to check out the PDA gives the list of the stuff he bought and associates them with the user's mobile phone's Bluetooth MAC address.

The data are analyzed and the user's profile gets more and more accurate. There are quite a few technologies used mostly in e-shops, like Amazon where it is easy to record what the user has bought and ad-aware applications which record which sites users visit.

Scenario

Mike is an 18 year old, first year undergraduate student. He goes to the supermarket once per week and spends around 50£ to buy food. Mike goes to the same supermarket every week and he likes to take care of his diet so he looks for food that has low carbohydrates and fat.

When he gets in the supermarket he gets a message from the basket that his favourite peanut butter is not any longer the one with the lowest fat but another one a bit more expensive is now available at the store. It also tells him that people with similar dietary habits also prefer to eat oat in the morning rather than the honey pops and it is actually cheaper. Mikes considered that he can afford to pay a bit more for the low fat peanut butter but he can not weak up in the morning without having his favourite honey pops.

He starts shopping and because yesterday his MP3 player broke he started looking to buy a new MP3 player. He goes where the MP3 players are sold. He queries with the PDA and he gets a list of products. He puts in his basket one made by Sony. It had 1GB of memory and it cost 100£. The systems checks the rest of the products and tells the basket that there is actually a better one at the same price with the same memory, with better sound quality (because of a specification I am not aware of) of a manufacturer Mike did not know. The system also suggest that if he wanted to wait, in a few days they are expecting the new iPods that have more memory, better quality, and cost less than the products that are on the shelves at the moment. Mike thinks that he can live a couple of days without an MP3 player so he makes a reservation for the ipods that are expected.

When he wants to go he knows the amount he has to pay he goes to the cashier, he does not wait at all he pays the amount he is supposed to and he goes.

Benefits

Benefits are both for the organisation of the market but also for the user.

For the managers, a customer that leaves satisfied from the shop is ensured that he will come back to shop again. They will also make their life easier because they will always know the merchandise they have, what they need to order, what sells most and different other statistics about the usage of the shop. They will not have to update their databases with new products because that will be done through the shelves. They will also save money from advertisements because the user in his visit will get all the information about the product he might need. Fewer personnel are necessary when such system is in use.

For the customer are the real benefits. They can shop a lot faster because the search for the best product will be easier and because by knowing the amount of money they will have to pay they are not going to wait in line at the cashier. They will also save money that will be able to spend on other products advertised to him which are picked because of his own preferences.

Risks

The main risk considered is anonymity and it is achieved since MAC addresses are associated with the profiles and not users. The main risk in such a system is when the user changes mobile phone (happens quite often) and the system has to train about his preferences from the beginning.

Insect Monitoring and Control Networks

Cyrus Hall
hallc@lu.unisi.ch
+41 58 666 4719
University of Lugano
Via Giuseppe Buffi 13
6900 Lugano Switzerland

August 31, 2005

1 Introduction

With the global transport of humans and animals as a part of the daily reality of the world, invasive species have ended up being spread at a speed never before seen. Climate change exacerbates the issue, enlarging the range of pests into regions where they have no natural predators. Insects are an especially troubling form of invasive species, and present a real danger to human life.

This paper proposes that such invasive insects could be monitored and controlled via micrometer scale sensor nodes and actuator devices. These nodes would be applied to insects by spraying or alternative methods. Once attached, they would monitor the behavior of the insect, and present corrective stimulus when disruptive behavior was observed. Since insect behavior is often individually chaotic but group coherent, such nodes would have to communicate with one another in order to determine the state of the individual. We will call these networks *hexa-nets* (insects are classified as Hexapods).

2 Use Case

Consider the case of Africanized bees ("killer bees") in the southern United States. Accidentally brought to Brazil, there range has increased North as temperatures rise. While they rarely kill humans, young children and the elderly are killed every year in attacks.

Bees, like most other insects, communicate with motion, sound, and the release of pheromones. When bees are disturbed by an intruder in their hive protection zone, they release *2-heptanone*, a pheromone. Complicated dances can then ensue, communicating the direction of a target, and/or to stabilize a given swarm.

A hexa-net could be deployed on an aggressive bee population, such as the Africanized bee, by several means. Most likely the bees could be smoked or sprayed with a solution containing the hexa-nodes. The nodes would be coated in material naturally adhesive to the bees, such as a synthetic pollen.

Once in place, the hexa-nodes would start monitoring both the bees motion and pheromone releases. Individual motion within a swarm event is mostly chaotic. As such, individual behavior would need to be communicated between nodes and correlated in order to determine group behavior. This also applies to pheromone release. A single individual releasing 2-heptanone may not signal a dangerous swarming event, but several tens or hundreds of bees doing so is a strong indicator.

Upon the detection of a likely swam attack, the hexa-nodes would attempt to change the behavior of the swarm. The methods to do this need further study, but one can imagine several scenarios. Hexa-nodes could release a stored conter-pheromone, a chemical that would breakdown or change 2-heptanone into a non-signaling agent. More direct action could also be taken, where hexa-nodes directly inject the bee with a toxic substance to stun or kill it, saving the human victim.

3 Necessary Technological Advancement

Much of the technology imagined here is decades away. In particular the power system would need to be radically more advanced than anything possible today. While much of the energy used could be harnessed from ambient sources, temporary storage before usage will remain a problem that requires a large amount of weight/space for the foreseeable future. It is possible that the hexa-nodes could gentle tap into the energy systems of the host insect, using metabolized sugars as a source of energy.

Radio communication between the nodes, while expensive in energy, could be opportunistic. Since insects are typically quite close together, especially when engaging in negative behavior, most communication could wait until hexa-nodes were very close.

The construction techniques for such nodes would involve molecular sensors. Such sensors would be make out of molecules themselves, and be designed so that the target moleculars would easily bind to the sensor. When a target molecule was captured, the weight would close a circuit, signaling it's presence. If tens of such sensors were placed together, a hexa-node could evaluate if a given compound was present. This technology is already being developed, but needs some time to continue to get smaller.

4 Benefits

There are two main benefits to hexa-nets. First, they could save both human lives and property. Be detecting harmful behavior such as swarming attacks or critical population levels, hexa-nets could try to control and limit negative outcomes.

Second, hexa-nets could gather important data on insect behavior. New techniques for passive protection from invasive species could be developed. This could include better materials for buildings or better agricultural techniques.

5 Risks

Environmental risks must be considered before a hexa-net-like system could be deployed. Out understanding of insect behavior and the environmental factors that influence it is still quite low. Introducing millions of small sensor nodes could be very disruptive to a very necessary part of our ecosystem.

Just as concerning could be the technology itself. A technology that can monitor and influence animal behavior could certainly be employed to do the same to humans.

6 Conclusion

Hexa-nets could be used to monitor and control insect behavior. Such networks would safeguard human interests while helping widening our understand of target insect populations. The information gained could be useful in developing new passive prevention measures (new materials, better location planning, etc).

Sensor Networks for Enhanced Human-Animal Interaction

Lucas Wanner
Laboratory for Software and Hardware Integration
Federal University of Santa Catarina
PO Box 476 – 88049-900 – Florianópolis, SC, Brazil
+55 48 331-9516 – lucas@lisha.ufsc.br

1 Description

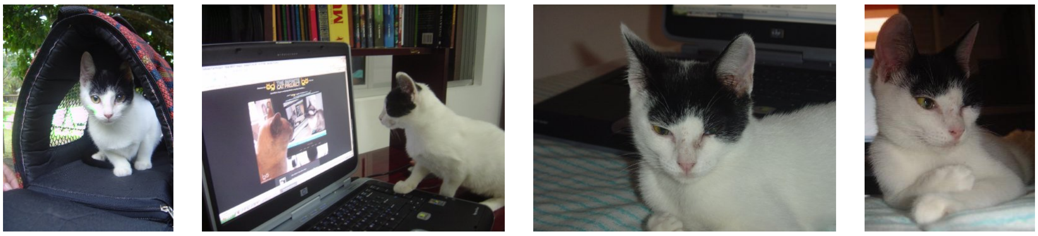
Many people regard their pet animals as part of their families. They relate to them by giving and receiving company, tenderness, and attention. After having a pet for some time, an owner usually knows, for example, when the animal is happy, sad, sleepy or perhaps sick. However, our comprehension of animal behavior and communication is somewhat limited. Animals communicate to humans and other animals through sounds and body language, be we cannot always tell what an animal is trying to communicate by its actions (e.g. barking, jumping up and down, moving things around the house).

In the not-so-distant future, advances in sensing technology will allow us to unobtrusively monitor a animal in order to *translate* its sounds and actions into human language. Very small networked sensors will be able to measure movement, muscular tension, body temperature, as well as capture sounds, images, and environmental conditions. These measurements will then be used to determine behavior though a pattern recognition system.

These systems will then interact with other devices, such as PDAs, television sets, or any other computer equipment in order to inform the owner what its pet is trying to communicate at the moment (if it is trying to communicate at all). One such device could inform, for example, that a dog is in need of attention, or that a cat doesn't like its new food brand, and is making a mess of the house in order to explain that to the owner. A user-feedback system will enable better data interpretation through machine-learning techniques, so the *translations* of the sensor readings into human language can get better and better with time.

2 Technical Requirements

There are two major requirements for this technology: miniaturization of components and development of efficient machine-learning systems for this particular problem. In order to be unobtrusive, sensor nodes placed, for example, close to the skin, would have to be just a few mi limiters in size, and built from materials that can cause no harm to the animal. Raw sensor readings would not be sufficient to determine relevant animal behavior data. These readings have to go through some sort of interpretation/machine-learning system (e.g. backpropagation neural network, etc.) in order to yield significant results. These systems will have to be developed in direct cooperation with biologists and animal behavior specialists, and will need a user feedback mechanism.



(a) Afraid (b) Curious (c) Sick (d) Relaxed

Figure 1: How is Johny feeling?

3 Scenarios

Figure 1 presents Johny the Cat at several different situations. In each of these situations, Johny has some very clear body positions and expressions that allow us to easily assert how he was feeling at those particular times. With a system such as the one described here, this interpretation power would be widely extended.

In a home environment, an owner could take better care of his pets needs, and share a more productive interaction with the animal. In a farm, an animal could be monitored for diseases and eating patterns. In the natural environment, scientists could collect fine-grain data in order to interpret wild animal behavior and habits, allowing them to create, for example, ideal environments and conditions for endangered species to breed in captivity.

4 Benefits

The main benefits of this system can be classified on a personal and on a scientific level. On a personal level, most people who own pets would probably like to better understand the behavior of his animal, which in turn can be considered a reflection of what the animal is *thinking* or reacting to. On a scientific level, our understanding of animal species could be greatly improved, allowing us to take actions towards their protection and well-being.

5 Risks

The main risk associated with this idea is animal safety. Every piece of equipment that is to be in direct contact with the animal must be manufactured from materials which are harmless to it. There may also be an issue of whether or not an animal has the right to privacy and not to be monitored, but that debate is well off the scope of this document.

B. Appendix B: Announcement, Rules and Results for the SFC

Embedded WiSeNts - Project FP6-004400

- Home
- Project
- Participants
- Documents
- Events
- News
- Press
- Internal
- Contact

Deutsche Telekom Laboratories An-Institut der Technischen Universität Berlin

Embedded WiSeNts

Information Society Technologies

Welcome to the *Sentient Future Competition* – created by the *Embedded WiSeNts Coordination Action*, and sponsored by the *Deutsche Telekom Laboratories* of the *Deutsche Telekom AG*.

Result Announcement

Embedded WiSeNts aims to advance the development of **Wireless Sensor Networks (WSN)** and their applications, especially in the form of **Cooperating Objects(CO)** – along a **Research Roadmap** toward **Visions for Innovative Applications**.

Your scenario can be relevant to any area of human activity - social, business or personal - in any setting - the home, office, factory, travel, sport, natural environment, etc.

This competition attempts to explore application areas that could potentially be realized once all the basic technology of **Cooperating Objects** is going to be in place.

Cooperating Objects are everyday objects equipped with a tiny computer, some means to gather information about their physical surroundings and to communicate it to other cooperating objects or computers. **Cooperating Objects** may share their knowledge in order to make decisions and perform actions such as raising an alarm, controlling a building's environment, actuating a vehicle's brakes or administering medication to a patient.

In the near future many parts of our environment will include a plethora of sensor nodes - very small, inexpensive computers equipped with devices for sensing or receiving information about the physical world in which they are located and performing simple actions. Sensor nodes communicate with each other and with other computers by wireless networking. They interact to share information and to perform more complex actions. Nodes that interact to perform tasks cooperatively in a manner that has a real effect are called **Cooperating Objects**.

For example , cars may detect the presence of other vehicles or pedestrians and transmit information about their presence to other nearby cars which may slow down when children are present, or when there is a lot of traffic ahead.

What may be possible in 10 yearstime - we are looking forward to find the most interesting and futuristic **Visions for Innovative Applications** in the field of Wireless Sensor Networks and Cooperating Objects

Scenarios somewhere near science fiction are welcome!

Prizes

1 st prize: 6.000 €

2 nd prize : 3.000 €

3 rd prize : 1.000 €

Dates

Competition opening : October 1 st, 2005

Deadline for applications : November 30 th, 2005

Notification : January 18 th, 2006

Application submission

Applications must be registered with title and author list at EDAS.

Please submit your application in three steps:

1. **Creation of a personal account on EDAS** (if you do not already have one)

2. **Registering your application** Click on the SUBMIT PAPER button on your SFC EDAS homepage. You should then see the web form for registering your application submission. Please fill in and submit the form. You will receive an acknowledgement of your application's registration.

3. **Uploading your paper** To upload your paper right after registering your submission, simply follow EDAS instructions on the acknowledgement page. Alternatively, you can upload your application later from your SFC EDAS homepage. After submitting your paper, you can revise it at any time before the submission deadline of November 30th, 2005.

General enquiries on the competition, please email to:

Sentient-Future-Comp@cl.cam.ac.uk

Or by conventional mail to:

Sentient Future Competition
c/o Prof. George Coulouris
Computer Laboratory
University of Cambridge
CAMBRIDGE CB3 0FD

Contributions will be evaluated by a jury from academia and industry.

The finalists will be invited to attend the awards ceremony taking place at the European Workshop on Wireless Sensor Networks 2006 (EWSN) on February 15 th, 2006, in Zurich.

Competition Rules

Download **competition rules** in PDF format.

Information Society Technologies

The Sentient Future Competition

Eligibility, Rules, and Regulations

1. Objective:

The ***Sentient Future Competition*** has been initiated by:

Embedded WiSeNts - ***Cooperating Embedded Systems for Exploration and Control featuring Wireless Sensor Networks***

a Coordination Action funded by the European Commission, IST/FP6 at the objective ***Embedded Systems***.

Embedded systems are increasingly used in networked environments. It is expected that ***Cooperating Embedded Systems***, especially sensor networks, will play an important role in multiple aspects of manufacturing, transportation, infrastructure management and simply everyday life.

To the main objectives of ***Embedded WiSeNts*** belongs the identification of most promising applications as well as identification of research challenges on the way to making this applications reality – **But which applications we expect 10 years from now**?

The ***Sentient Future Competition*** **is created to generate** ***Visions for Innovative Applications*** that could potentially be realized once all the basic technology of ***Cooperating Objects*** is going to be in place.

2. Eligibility

- Applicants of any age or nationality may enter
- Applicants must not be a member of the *Embedded WiSeNts* consortium or an employee of one of the Sponsors (students or institutes situated at one of the consortium members but not directly involved within the *Embedded WiSeNts* project may apply)
- Applicants may be individuals or teams (no limit on size)
- Multiple submissions allowed; each application will judged separately and is qualified for winning a prize

3. Rules

- The application must be in English and must be typed.
- Supplementary material to demonstrate or visualize the application is allowed, e.g. videos, animations, simulations. In the case that this material in a non-electronic form a typed description has to be provided.
- Complete applications must be mailed or emailed.
- Each application will be acknowledged by email, or mail if no email address is available.
- Embedded WiSeNts assumes no guarantee or responsibility for lost or late applications or any technical failures of transmission etc. You are recommended to keep a copy of the applications.
- Only complete applications will be reviewed.

4. Timeline

- **Competition opening**: October 1st, 2005
- **Deadline for applications**: November 30th, 2005
- **Notification**: January 18th, 2006

- **Awards ceremony**: at the European Workshop on Wireless Sensor Networks 2006 (EWSN) on February 15th, 2006, in Zurich

5. Prizes

The three finalists will be awarded with cash prizes:

1st prize: 6.000 €
2nd prize: 3.000 €
3rd prize: 1.000 €

6. Judging

All applications will be evaluated by a jury from academia and industry following the criteria:

- Originality of concept and vision
- Innovation, technical progress
- Impact – social, economic, environmental

7. IPR

Successful entries will be published and contestants will agree to place their contribution in the public domain.

8. Application form

The complete application form consists of:

- Title of the application
- Description of the application (typed concept, visions, ideas)
- Optionally: Supplementary material like videos, animations etc.
- Personally data:
    - Name / Team
    - Organization / company
    - Address
    - Email address
    - Phone / fax

9. Submission address

Please send your complete application by email to:

Sentient-Future-Comp@cl.cam.ac.uk

Or by conventional mail to:

Sentient Future Competiition
c/o Prof. George Coulouris
Computer Laboratory
University of Cambridge
CAMBRIDGE CB3 0FD

10. Sponsors

We thank the ***Deutsche Telekom Laboratories*** for sponsoring and promoting ***The Sentient Future Competition***.

Embedded WiSeNts - Project FP6-004400

Sentient Future Competition - Result Announcement

Home

Project

Participants

Documents

Events

News

Press

Internal

Contact

The Embedded WiSeNts Sentient Future Competition **Judging Panel** is happy to announce the following results. The judging process was a rigourous one following the criteria defined in the **competition announcement** and **rules**. 79 entries were received and the judges were impressed with the high quality of the entries. All entries were reviewed by three members of a **panel of 24 reviewers.** A shortlist of entries was selected based on these reviews. The shortlisted entries were then carefully reviewed by all members of the distinguished judging panel who reached the decisions shown below.

Prizes will be awarded at a **special session** of the **European Workshop on Sensor Networks 2006** (EWSN '06).

1st Prize - €6000:

Large Scale Body Sensing for Infectious Disease Control (pdf)

Markus Endler
Department of Informatics
Pontifícia Universidade Catolica do Rio de Janeiro
Rio de Janeiro, Brazil

2nd Prize - €3000:

BIN IT! The Intelligent Waste Management System (pdf)

David Schoch - Student of Geography at the University of Zurich
Matthias Sala - Student of Computer Science at the ETH Zurich

3rd Prize - €1000:

Vision of Congestion-Free Road Traffic and Cooperating Objects (pdf)

Ricardo Morla
PhD student in Computer Science, Lancaster University, Researcher, INESC Porto

Highly commended entries

Ambient Intelligence by Collaborative Eye Tracking (**pdf**), Eiko Yoneki (University of Cambridge, UK)

eLink10 headset (**pdf**), Phillip De Caux (University of Liverpool, UK)

Embedded WiSeNts & Agnostic Algorithms of Creation (**pdf**), Panagiotis Bairaktaris (City University, UK)

Father in the Womb (**pdf**), Tiago Camilo (University of Coimbra, PT); Jorge Silva (University of Coimbra, PT); André Rodrigues (Instituto Superior de Contabilidade e Administração de Coimbra, PT); Eduardo Sá (PSIC, DZ)

LocuSent - locust control (**pdf**), Milo Lavén (ArtCore Sthlm, SE)

WISPHER: cooperating WIreless Sensors for the Preservation of artistic HERitage (**pdf**), Franco Raimondi (University College London, UK); Davide Del Curto (Politecnico di Milano, IT)

PerSens: Personality Sensors (**pdf**), Zinaida Benenson (RWTH Aachen University, DE); Mesut Günes (RWTH Aachen University, DE); Martin Wenig (RWTH Aachen University, DE)

Sentient Guardian Angel (**pdf**, **animation**), Marcus Christ, Gerald Eichler, Klaus Miethe, Stefanie Richter, Jens Schmidt, Jens Wukasch (DE)

SmartSoot (**pdf**), Patrick Andrews (break-step productions ltd, UK)

Judging Panel

George Coulouris, Cambridge University (chair)
Philippe Bonnet, University of Copenhagen
Andy Hopper, Cambridge University
Friedemann Mattern, ETH Zurich
Pete Steggles, Ubisense Ltd.
Christian Wolf**, Deutsche Telekom Laboratories**
Adam Wolisz, Technical University of Berlin

Reviewers

Michel Banâtre *INRIA*, Sebnem Baydere *Yeditepe University*, Philippe Bonnet *University of Copenhagen*, George Coulouris *University of Cambridge*, Laura Feeney *Swedish Institute of Computer Science*, Vlado Handziski, *Technische Universitaet Berlin*, Paul Havinga *Universiteit Twente*, Eric Jul *Univ. of Copenhagen*, Maria Lijding *University of Twente*, Pedro Marron *University of Stuttgart*, Friedemann Mattern *ETH Zürich*, Ivan Maza *University of Seville*, Nirvana Meratnia *University of Twente*, Daniel Minder *University of Stuttgart*, Aníbal Ollero *AICIA-University of Seville*, Chiara Petrioli *University of Rome La Sapienza*, Kay Roemer *ETH Zurich*, Silvia Santini *ETH Zurich*, Roland Schwaiger *Deutsche Telekom Laboratories*, Pete Steggles *Ubisense Ltd*., Thiemo Voigt *Swedish Institute of Computer Science*, Christian Wolf *Deutsche Telekom Laboratories*, Adam Wolisz *Technical University of Berlin*, Andrea Zanella, *University of Padova*

G. Coulouris, I.Piens 17 January 2006

Home Project Participants Documents Events News Press Internal Contact

C. Appendix C: Selected Entries from the SFC

Sentient Future Competition
Large scale body sensing for Infectious Disease Control

Markus Endler
Department of Informatics
Pontifícia Universidade Católica do Rio de Janeiro
R. Marquês de São Vicente, 225
22453-900 - Rio de Janeiro, Brazil
endler@inf.puc-rio.br

1. SENSOR NETWORKS TO SOLVE MAJOR PROBLEMS

In the last decades, computer researchers have come up with several applications for wireless and sensor technology that are strongly focused on military activities, (personal and corporate) productivity-enhancing processes, or entertainment, many of which, we believe, are less urgent than other global problems like Uncontrolled Population Growth, Non-sustainable use of natural resources, Natural Disaster Relief, and Infectious Disease Control. Hence, we claim that these other problems should become the agenda of future research and development in this area.

In this sense, we chose one of these problems - Infectious Disease Control - and in the following outline a possible future use of sensor networks for monitoring and controlling infectious diseases in large animal (and maybe also human) populations. Because of the several intricate ethical issues involved in monitoring humans, we prefer to explain our application in terms of non-human populations.

The recent news about the Avian influenza disease have shown how fast a mutant and lethal virus disease can spread around our globe, putting in danger large populations of humans.

On the other hand, the relatively large incubation time of the virus makes it difficult to detect infected animals at an early stage. Therefore, large amounts of animal must be pro-actively sacrificed at any suspicion of an infection.

The other problem is of scale. Since our society is raising animals (cattle, pork, chicken) in such a large scale in an industrial setting (with insufficient space and feeding them badly) we have become unable to monitor each animal's health, and avoid the spreading of diseases at early stages.

Hence, in our point of view it would be very important to develop sensors and an infra-structure that could continuously monitor the health conditions of large-scale animal populations regardless of their location. And using sophisticated methods for automated diagnosis, one would enable warnings of disease or infection suspects, and allow for early control measures by the farmers or the agricultural authorities.

This problem area is particularly important in Brazil, since a significant part of its economy is based on the export of food and meat. For instance, Brazil is the world's biggest exporter of cattle meat handling US$ 2,5 bilions annually. However, because of the current incidents of aftosa fever in some regions of Brazil in 2005, there will be a lost of about US$ 270 millions.

2. REQUIRED TECHNOLOGY

With the miniaturization of chips, soon it will be possible to produce penny-size body sensors with small flash memory and short-range wireless communication capabilities. These sensors could be attached to (or implanted in) specific parts of animal, and would be able to probe physical (e.g. temperature, ECG, blood pressure), chemical (e.g. pH, toxins) and biological (e.g. glucose, protein) properties of the body.

This data would be stored in the on-chip memory, and could be transferred through the wireless interface to *collector nodes* (at base-stations installed at gateways or close to the food or water dispensers) as soon as the animal gets close to such a base-station. These base-stations would have a wireless connection to the farmer's office computer, where all the collected data would be analyzed and visualized by specific software for infectious disease control.

The chip would carry the animal's identification and other data, such as age, gender, etc. Moreover, each time two animals get close to each other, the corresponding chips would also exchange data, in order to register this encounter on each chip. This would help to detect whether there is some possibility of infection among two animals.

The chips would have very low power consumption (e.g. few μWatts), and would be powered by several, complementary energy sources, such as battery, solar energy, motion or thermal energy. Such sensors with integrated low-cost radio interfaces, called Ultra-low Power Radios (ULPR), are already being developed [2]. They use specific propagation in and around a body using specific characteristics of of biological tissue, and are powered by micro-generators [1].

Some future versions of such chips may also be equipped with GPS sensors, allowing to track the exact location of each animal.

3. SCENARIO

The following scenario illustrates the use of the envisaged technology (let's call it the *Animal Health Monitoring System - AHMS*) in controlling and avoiding the spread of infectious diseases at an early stage:

> Consider a cattle farm with a large number of cows (e.g. 20,000 or more), where the animals are regularly moved among several pastures, and where all of the cows are equipped with the AHMS measuring glucose and toxin levels. Moreover, consider that some of the pastures are at the border to another country, where sanitary control is much more relaxed[1], and where some cows have an infectious disease which can be diagnosed by a sudden, but short period of high body temperature.

By continuous monitoring the toxin levels of all the cows, the farmer may early detect that there is some problem with the food or water given to the cattle. Additionally, with AHMS a farmer would be able to monitor the daily temperatures of his animals, and as soon as some animals in the border pasture get the symptoms of the disease, the farmer would be able to conclude that some of his cows have probably been infected. He would then isolate the infected animals from the others, or if necessary, sacrifice them in order to avoid further spread of the infection.

Even for the case that the health problems of an animal disease show up only when the meat is consumed, the AHMS could be used for tracing the health condition history (and the behavior) of the animal(s) who's meat caused the health problems. In fact, this could also help to identify characteristic symptoms of unknown diseases and be used by government agricultural agencies for generating cattle health certifications.

Additionally, by using location technologies the scenario can be even more interesting for disease control. For example:

- If the AHMS chips had GPS sensors, the farmer would even be able to detect where most probably is a hole in the fence that allows his cattle to get into close contact with the cattle of the neighbor farm.
- By tracking which other animal has been in contact with the infected ones some days before or after the suspicious symptoms were detected, the farmer would be able to widen the group of animals to be isolated or sacrificed.

4. MAIN TECHNOLOGICAL CHALLENGES

In spite of the many benefits that such application might bring, unfortunately, so far, the required technology is not sufficiently accurate and reliable for such a use. In the following, we point to what we believe are the major technological challenges that have to be overcome.

[1]This is the probable cause of the recent aftosa fever in some regions of Brazil.

4.1 Improvement of sensors for biological and chemical measurements

It is well known that several diseases can be detected diagnostically only through very specific analysis of blood (or other body substances), through detection of external symptoms, or a combination of both. For the former case, sensors would have to be much more sophisticated and would have to have access to blood veins or body organs, etc. Despite the several significant advances in medicine, we believe that there still are a strong demand of research effort in order to enable the development of cheap sensors for "deep body monitoring".

4.2 Detection of externally visible symptoms

As mentioned, many diseases are characterized by a combination (and timely correlation) of internal and external symptoms, and hence cannot be properly identified measuring only physical, biological, or chemical data. For example, the Malignant catarrhal fever has external symptoms such as nasal and ocular discharges, conjunctivitis, drooling, hematuria, necrosis and blunting of buccal papillae, enlargement of lymph nodes, diarrhea, among others [4]. Since it is virtually impossible to instrument an animal with sensors to detect all such kinds of symptoms, it would be necessary to identify such symptoms by other means, such as through video cameras, etc. However, such automated detection of external symptoms at individual animals within a large groups is certainly a complex problem in image recognition.

4.3 Development of micro-size and cheap power generators

Despite the current efforts to produce motion and thermal power generators, so far these are still very expensive to be deployable in large scale, and to big and heavy to be attached to or implanted in animal bodies. Here we envision need of strong interdisciplinary research in several areas of health and natural sciences.

4.4 Low-power radio transmission

In recent years, several advances in low-power (and low-range) radio transmission have been done. More recently, the wireless technology ZigBee [3] has been announced, but according to specialists it's communication efficiency and power consumption are still inappropriate for simple sensor networks. Hence, not only hardware must improve, but research must also be done in communication protocols for efficient and opportunistic wireless transmissions.

4.5 Dealing with sensor outage

Sensors, in general, may fail due to many possible problems, ranging from lack of power supply to physical damage. This is the reason why traditional sensor network research counts on redundant nodes and resources. The problem with body sensors is that, so far, they are not cheep and tiny enough so that an animal could be *instrumented* with many of them. On the other hand, data from each individual animal is necessary for a complete monitoring of a herd of animals. Therefore, body sensors must still become smaller and cheaper (and have a reliable power source) so that they can be used for such application.

4.6 Dealing with unreliable wireless communication and unpredictable movements

It is well known that short-range wireless communication is very unreliable, not only because of radio interference, but also because nodes (sensors) may be in constant move. For body sensors, this is even worse, as animals move in unpredictable ways and sometimes gather at some places, creating "natural" obstacles for both peer-to-peer and sensor-to-base-station communication. Therefore, we believe that much R&D must be done for creating efficient, and more robust (multi-hop) communication protocols for sensor networks.

5. CONCLUSION

In this position paper we presented our vision of a future application of sensor and wireless technology that would be useful for dealing with the acute and important problem of infectious disease control. Similarly, there are also many other important and complex real-world problems, such as environmental protection, natural disaster forecast and relief, etc. which may safe many lives today, and/or guarantee life of future generations, and which should be the focus of current (inter-disciplinary) research and development.

6. REFERENCES

[1] IMEC. Micro-power generation: R&d fact sheet. Web page. http://www.imec.be/human/brochures/micropower.pdf (Last visited: October 2005).

[2] IMEC. Ultra low-power radios. Web page. http://www.imec.be/wireless/ulp-radio/ (Last visited: October 2005).

[3] G. Legg. Zigbee: Wireless technology for low-power sensor networks. Web page, May 2004. http://www.techonline.com/community/ed_resource/-feature_article/36561 (Last visited: October 2005).

[4] R. R. Rech, A. L. Schild, D. Driemeier, and et al. Malignant catarrhal fever in cattle in rio grande do sul, brazil: epidemiology, clinical signs and pathology. *Pesq. Vet. Bras.*, 25(2):97–105, June 2005.

BIN IT! – The Intelligent Waste Management System

Position paper transmitted to the Sentient Future Competition

David Schoch
University of Zurich
Switzerland
d.schoch@access.unizh.ch

Matthias Sala
ETH Zurich
Switzerland
salam@student.ethz.ch

ABSTRACT
Littering is an urgent problem in urban environments. Therefore, a more efficient and sustainable waste management system can implicate a higher life quality and less costs for the city authorities. We propose an RFID system that tracks pieces of waste and encourages the correct disposal by financial incentives. Our solution is easily realisable and stands out by its high social, economic and ecological relevance.

1. MOTIVATION
Around the globe, more and more litter is being thrown away carelessly or dumped illegally in streets, in public spaces or in nature. Littering and the wrong waste disposal respectively affect adversely the public order, lead to higher costs for the cleaning teams and to a diminished quality of life for society. This emerging trend has to be given due attention and appropriate measures have to be launched to counter it.

In many countries, state authorities have been working on concepts to give incentives against littering and the incorrect waste disposal. But often these campaigns tend to fall on deaf ears in society because the waste management is often organised in a far too complicated way and there are not enough incentives for a social, economic and ecological waste management. This is the reason why we have developed an intelligent waste management system that allows city authorities to tackle the problem at its roots, this means on the street or at other neuralgic places, there where littering is most obvious.

2. PROPOSED SOLUTION
We imagine that in the future the littering problem can be solved using the tracking possibilities given by the RFID technology [1]. The person who disposes the waste is in possession of a *collection card*. Is he or she throwing a piece of *waste* in a *bin* or disposing recyclable material in a *recycling container*, the *bin* or *recycling container* identifies it and a certain deposit will be credited to his or her *collection card*.

The intelligent waste management is based on four *cooperating objects* described in the following subsections:

2.1 Waste
All different kinds of consumption goods like packages of fast food restaurants, tetra packages, bottles, jam jars, cans, batteries, etc. get equipped with standardised RFID tags in the factory when they are produced.

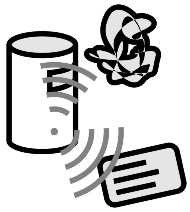


Figure 1: Wireless communication between waste, bin and collection card.

2.2 Bin & Recycling Container
The bins and recycling containers are inwardly provided with a reader and a writer. The bins are distributed all over the cities as usual. All objects that are not meant to be recycled can be dumped there. The recycling containers are allocated at central and highly accessible locations, but they do not have the same geographical distribution density as the bins.

2.3 Collection Card
The collection card has the same size as a credit card and has an embedded writable RFID chip. Collection cards are nonpersonal and are available at no charge.

2.4 Refund Station
Refund stations are explicit desks, specialised vending machines or retailers (e.g. fast food restaurants) equipped with RFID readers and writers and connected to the global waste directory. The amount collected with the collection card is refunded here.

3. STEPS IN DETAIL
Figure 2 shows the cycle of waste within the intelligent waste management system in more detail. It includes the following steps:

Production (1) The product gets equipped with a standardised RFID tag and the number is registered in a global directory.

Purchasing (2) The product is bought by a consumer. The consumer receives a collection card.

Waste Arising (3) The product is used and waste is produced.

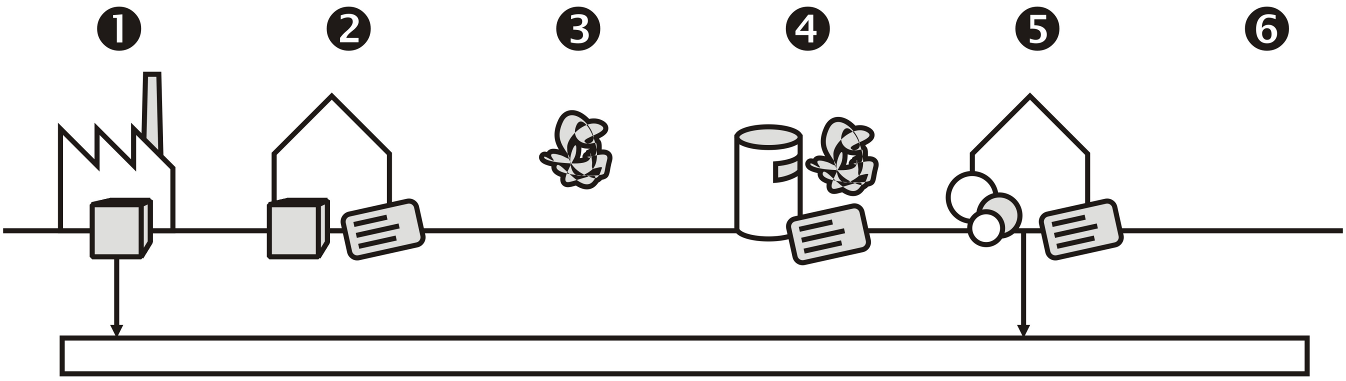


Figure 2: Cycles within the intelligent waste management system.

Waste Disposal (4) The waste is dumped in a bin or in a recycling container and the corresponding number is stored on the collection card.

Refundment (5) The amount refunded is calculated on the basis of the numbers on the collection card. The numbers of the disposed objects are removed from the global directory.

Recurrence (6) This cycle recurs at any time. The collection card can be used further on.

4. SUSTAINABILITY

On the whole, this visionary scenario is easily realisable and modifiable. It draws on all of the *three pillars of sustainability* [2].

4.1 Social

In general, the appropriate disposal of waste is of very high importance for society. The sensitisation of society for a sustainable treatment of the environment is an indicator of the prosperity of a country and it helps to strengthen the **well being** of its population. The intelligent waste management system generates a certain climate on the street that influences the waste offenders in a positive way. We can also imagine that certain persons would be attempted to collect the waste of others.

4.2 Economic

The immense costs of waste disposal that the state has to pay can be reduced by a systematic waste management policy. In states like Singapore, that maintain a very repressive policy, this system could lead to a rethinking. In addition, the producers profit from the lower production costs by the reuse of recyclable materials. But also the consumer side should be recompensed for the proper use of the waste management system by selective financial incentives. A **win-win situation** should be established.

4.3 Ecological

The use of the intelligent waste management system stops the further contamination of our environment and combats the **exploitation of non-renewable resources**.

5. POSSIBLE EXTENSIONS

The proposed infrastructure is adaptable for different needs, as described below:

If waste without an RFID tag or recyclable waste is thrown into a bin, **no money** will be transferred. This system can be expanded by defining which waste can be dumped in which bin or recycling container. The more products get equipped with an RFID tag, the more accurate and efficient it is.

To avoid possible financial fraud, a retailer such as a fast food restaurant may use the system to collect points (instead of money) in order to reward frequent clients (**customer retention**).

In a brave new world scenario, every piece of waste would be equipped with RFID tags. Therefore, an authority (e.g. the producer) could track back the origin of illegally disposed waste and **fine** the polluter on one's own account. This scenario however leads to some privacy concerns which are discussed in the next section.

6. DISCUSSION

Similarly to other RFID solutions [3] [4], **data privacy** is a severe issue. That is why we consider it as important to save only nonpersonal data on the collection card. This makes the collection card transferable from one person to another. As mentioned in section 5 above, a personalisation of the collection card could be implemented as a next step, at least for certain products.

To organise this waste management system efficiently it is important that many enterprises **participate**. Fast food restaurants (*Mc Donald's*, *Burger King*, *KFC*, etc.) that often suffer from their bad image concerning waste disposal management could profit a lot.

Further, to prevent the **abuse by the reuse** of a certain object, the reader has to be installed inside the bin or container, so that the rubbish is not identified until it is inside and cannot be taken out again by people who try to cheat.

Additional security is given by the global directory that prevents multiple refundments. The refund station verifies each number on the collection card and deletes them from the global directory. If there is the same number on the collection card more than once, the corresponding amount is credited one time only. Therefore, a **fraud** cannot debit an item illegitimately, except he would be faster than the honest collector.

Whether the producer or the consumer has to **pay the deposit** is a controversial question as well. Concerning this matter, there are two possibilities. Either the client pays the amount of the deposit when he or she buys the item in terms of a tax rate (*polluter pays principle*) or the producer pays it. But the latter alternative is unlikely to happen without a price markup, unless the collecting card is linked to a customer retention system.

Solar cells on the top of the bins and recycling containers could provide the power supply for the technical equipment.

7. CONCLUSION

BIN IT!, the intelligent waste management system, is easily realisable from a technical point of view. On the other hand, it is of high social, economic and ecological relevance for society. These two factors combined give this visionary scenario great chances to be implemented. But the discussion shows as well that there would be some challenges to be accomplished, especially if this system should be dispersed over a large geographic perimeter.

8. REFERENCES

[1] A. Niemeyer, M. H. Pak, and S. E. Ramaswamy. Smart tags for your supply chain. In *The McKinsey Quaterly*, Number 4, 2003. Found on `http://www.lwcresearch.com/filesfordownloads/Smarttagsforyoursupplychain.pdf` (accessed in January 2006).

[2] G. H. Brundtland. *Our Common Future. World Commission on Environment and Development.* Oxford University Press, Oxford, 1987.

[3] S. A. Weis, S. E. Sarma, R. L. Rivest, and D. W. Engels. Security and Privacy Aspects of Low-Cost Radio Frequency Identification Systems. In *Lecture Notes in Computer Science*, Volume 2802, 2004, Pages 201 – 212.

[4] S. E. Sarma, S. A. Weis, and D. W. Engels. RFID Systems and Security and Privacy Implications. In *Lecture Notes in Computer Science*, Volume 2523, 2003, Pages 454 – 469.

Sentient Future Competition: Vision of Congestion-Free Road Traffic and Cooperating Objects

Ricardo Morla
Lancaster University and INESC Porto
R. Roberto Frias, 378
Porto, Portugal
ricardo.morla@inescporto.pt

ABSTRACT

This paper presents a vision of cooperating vehicles that help keep roads free of traffic congestion. This vision explores the concept of dynamic time-space corridor that can be negotiated between cooperating vehicles to guarantee congestion-free journeys from departure to arrival.

1. VISION

This vision of the future is motivated by the increasing traffic congestion around our densely populated metropolitan areas. There is no need here to reference the numerous studies on traffic safety and pollution carried out by governmental agencies over the years or to bring forward accident, carbon dioxide, and driver-stress figures. Everyone that has been in a large city in rush hour has most likely experienced how stressful it is to be locked in traffic, noticed the pollution in the air, considered how they could have been injured on the road, and wondered how much better their lives would be without traffic congestion.

Typical science fiction solutions to this problem of traffic congestion first come to mind, including for example the teleportation devices in Asimov's *It's Such a Beautiful Day* story or the ability to travel between alternate history Earths in Asimov's *Living Space* story. However, here we are not restrained only by our imagination but want to consider traffic congestion solutions that can plausibly be built within the next ten years. As such, we assume the following:

- In ten years, vehicles will be able to communicate, to sense their environment, to control their speed and direction, and in general to cooperate with each other.
- In ten years, numerous objects on the urban landscape will similarly be able to communicate and sense their environment – we are thinking for example of communicating and sensing signposts, sidewalks, and street lamps.

These seem reasonable assumptions. Manufacturers are already enhancing cars with sensors that help drivers to park and providing GPS compasses as standard equipment on luxury cars. Reasonably, full integration of on-board, software- and hardware-improved computers with wireless communications and environmental sensors is within ten years' reach. Furthermore, trials of numerous networked and sensing objects have been conducted in urban areas. This is a first step towards the full deployment of such objects throughout cities and metropolitan areas.

Our vision is that traffic congestion can be prevented with the help of these cooperating vehicles and urban landscape objects. In particular, we see these cooperating objects helping people drive more intelligently – or rather more cooperatively – with the aim of preventing congestion. Some laboratory prototype vehicles may today already detect the proximity of other vehicles or obstacles and automatically break to prevent collisions, or detect traffic congestion ahead and suggest alternate routes to drivers. Our vision is that of a solution that is beyond what these prototype vehicles can do to alleviate traffic congestion. In particular, with the help of cooperating objects we expect to prevent congestion before it occurs, self-regulating traffic such that e.g. avoiding collisions and finding alternate congestion-free routes may no longer be necessary to prevent congestion. In our vision, cooperating vehicles help to self-regulate traffic by negotiating in advance a clear corridor in space and time that goes through the roads of their intended journey. Such a corridor is much like a Time-Division Multiple-Access (TDMA) data slot that propagates through a communications channel. A vehicle that obtains access to such a time-space corridor will not experience congestion as other vehicles will manoeuvre to keep such a corridor unobstructed. In our vision, all the vehicles in what otherwise would have been a traffic jam have their own time-space corridors and, as such, move without causing or experiencing congestion. This is the core of our vision of congestion-free road traffic.

The following sections describe in more detail the system that we have envisioned to support congestion-free road traffic using cooperating vehicles and urban landscape objects.

2. ENVISIONED SUPPORTING SYSTEM

2.1 Time-Space Corridor

The major concept of our vision is the time-space road corridor that we also term virtual vehicle slot. Virtual vehicle slots propagate through a lane of the road at the recommend speed of that lane (see fig. 1). Once a virtual slot is assigned to a vehicle it cannot be overrun by other vehicles. On one hand, vehicles moving in their virtual slots will not overrun the virtual slots of other vehicles as 1) the speed of virtual slots on the same lane is the same; and 2) virtual slots are long enough to guarantee a minimum safety distance between vehicles of consecutive slots. On the other hand, vehicles that have not been assigned a virtual slot will have to avoid overrunning virtual slots by e.g. changing lane or increasing their speed. As such, a vehicle to which a virtual slot is assigned is guaranteed to arrive at its destination without experiencing traffic congestion. For example, we expect lane junction congestion to be prevented as virtual slots from incoming lanes are synchronised and propagate to the outgoing lane at the lane's recommended speed. Similarly, we expect that virtual slots will allow vehicles to maintain their speed and as such help prevent e.g. wave phenomena typical in traffic congestion in which vehicles periodically accelerate and then almost immediately have to break.

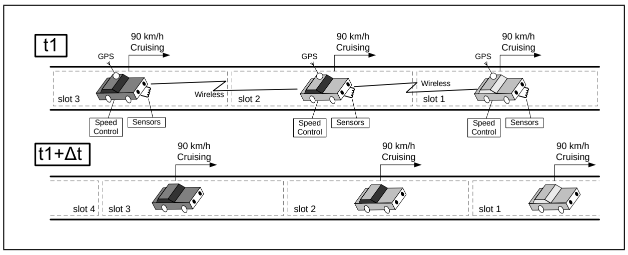


Figure 1: Example of a single lane with moving virtual vehicle slots. Notice how each slot moves forward with time at the recommended speed of the lane (90 km/h). Notice also that the vehicles communicate with each other, determine their position, sense their environment (e.g. proximity detection), and control their speed in order to keep to their moving virtual slots. (Note that cruising vehicles have zero acceleration.)

2.2 Cooperating Vehicles

In our vision, cooperating vehicles that can sense their environment will be able to implement this virtual slot system. These vehicles will be able to determine their position, speed, and direction and then successfully negotiate access to a virtual slot. Once a slot is assigned to the vehicle, the vehicle must not stray from the slot and thus speed and direction must be controlled. We don't expect vehicles to be able to fully and automatically 'drive' themselves in ten years – this will likely take longer to achieve. However, in ten years we expect vehicles to be able to suggest appropriate action to drivers such as reducing or increasing speed. For example, in lane junctions, two vehicles driving on different lanes will detect that their virtual slots will collide once their lanes have merged. The vehicles will negotiate their new slots on the outgoing lane (e.g. slightly offsetting the slots in opposite directions so they don't overlap) and inform their drivers that they should accelerate or break just enough to keep to the new slots.

Figure 2 illustrates this example. At time t1 the vehicle on the right lane (slot 2) needs to change lane. This vehicle would have a number of approaches to do so. 1) This vehicle breaks and waits for an opening on the left lane. The vehicle in slot 3 would not be affected, but this would cause the vehicle in slot 2 to be left behind its slot, to run into new slots that would potentially appear behind it, and to cause traffic congestion. 2) This vehicle keeps its speed and changes to the left lane, not keeping the safety distance to the vehicle in slot 3 behind it (fig. 2, option a, time t1 + Δt). This would likely cause the vehicle in slot 3 to do an emergency break, potentially running into slot 4 and starting wave congestion. 3) This vehicle communicates with the vehicle in slot 3 to attempt to coordinate the lane change (fig. 2, option b, time t1 + Δt). As a result, the vehicle in slot 3 would slightly delay its slot (breaking) and the vehicle in slot 2 would slightly advance its slot (accelerating) so that upon lane change the safety distance is maintained and the vehicles can keep to their new, offset slots. Note that offsetting these slots requires more than the coordination between vehicles in slots 2 and 3. In fact, the vehicle in slot 3 must coordinate with the vehicle in slot 4 so that slot 3 does not run into slot 4 as it temporarily lags behind. This approach would effectively prevent congestion as vehicles cooperate to keep to their slots.

2.3 Self-regulating flow control

In addition to controlling the speed and safety distance between vehicles using the virtual slot system, we must limit the rate of vehicles that enter a lane and make sure that the rate of vehicles that exits the lane is not inferior to the rate of entry. We envision a mechanism to control the inbound and outbound vehicle flows of a lane and prevent traffic congestion. This mechanism is two-fold.

Firstly, our cooperating vehicles must allocate a virtual slot in a lane before they enter that lane. Failure to allocate such a slot, namely in the case where the lane has reached the maximum inbound vehicle flow, will result in the vehicle not being allowed to enter the lane. Thus vehicles self-regulate the inbound flow of a lane by abstaining from entering the lane at peak conditions. Notice that virtual slot speed and length determine the maximum virtual slot rate. If the inbound traffic flow exceeds the maximum slot rate then the distance between vehicles diminishes. This forces drivers to maintain safety distances by reducing speed and, as such, causes congestion. In order to prevent such congestion, slot allocation fails in our envisioned system when inbound traffic flow is larger than maximum slot rate.

Secondly, outbound flow must not be inferior to inbound flow if congestion is to be avoided. We try to better understand outbound flow by considering what happens to vehicles when they leave a lane. Outbound vehicles will either enter another lane or stop at a parking space. Eventually however, every vehicle will finish its journey at a parking space. Difficulty in finding parking space will diminish the outbound flow of parking vehicles and potentially lead to congestion. In our vision, the urban landscape is full of different sensing and cooperating objects. In particular, drivers will rely on these objects to find available parking space. These objects can be, for example, wireless sensor networks deployed on sidewalks and that can detect the presence of vehicles on nearby parking spaces. Moreover, these objects can cooperate with vehicles that need to park by making parking space reservations and preventing other vehicles to park in places that have already been reserved. For an end-to-end approach to traffic congestion, vehicles have to allocate their destination parking space before they start their journeys – thus self-regulating outbound as well as inbound flows.

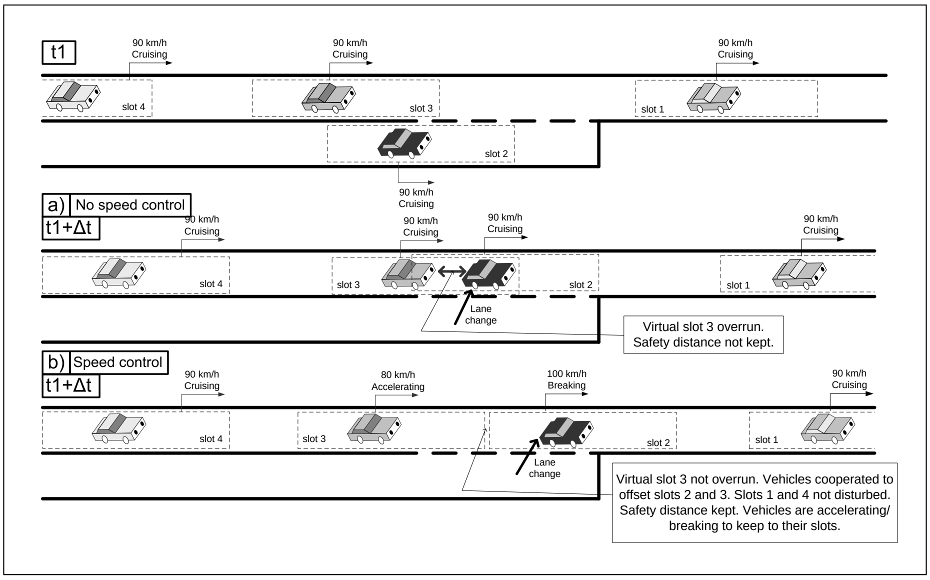


Figure 2: Example of merging lanes a) without and b) with vehicle cooperation.

3. SUPPORTING SIMULATIONS

We have used a third-party open source road traffic simulator to test the concepts of our vision, namely the virtual vehicle slot. The third-party simulator source code and papers on traffic simulation in general and on wave phenomena in particular can be found at [4]. Figure 3 shows congestion on a typical lane junction. Notice how vehicles have to stop and queue to change to the main lane. When a vehicle with a slow speed changes to the main lane, it will cause the vehicles behind it on the main lane to reduce their speed to prevent them from colliding with the slow vehicle ahead of them. This causes congestion and in particular the wave phenomenon that can be noticed on the curve of the main lane. Compare this with fig. 4 in which vehicles coordinate lane change with the vehicles on the main road. Notice in particular that 1) the inbound flow on both lanes and the simulation time are the same as those on fig. 3 and that 2) no wave phenomenon or congestion in general occurs in fig. 4 as vehicles coordinate lane change with the vehicles on the main lane.

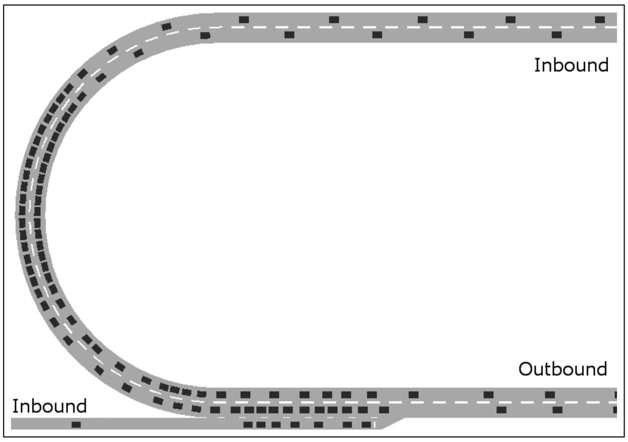


Figure 3: Typical scenario provided in the original simulator source code. Notice the congestion.

4. RELATED WORK

Our review of related work on using cooperating vehicles for preventing traffic congestion identified two separate research efforts.

Firstly, we have identified research whose main focus is on road traffic per se. For example, the U.S. Intelligent Transportation Systems (ITS) program [3] has proposed new initiatives such as integrated corridor management systems, cooperative intersection avoidance systems, and vehicle infrastructure integration. Another example is the Japanese ITS program that focuses e.g. on vehicle information and communication systems (VICS) [2] and on advanced cruise-assist highway systems (AHR) [1]. These programs build on road network planning, on vehicle sensing, and on vehicle-to-road communication to prevent congestion and avoid collisions. Cooperation between vehicles is only used to support collision avoidance and not to prevent congestion as in our envisioned solution.

Secondly, we have identified research whose main focus is on communications, sensing, and software for cooperating vehicles. For example, research at Lancaster University [6] has yielded an autonomous vehicle capable of cooperative behaviour without human control and of autonomous navigation. Another example is the ITS work by NEC [5] that focuses on e.g. congestion monitoring using sensor information from vehicles (termed Probe Information System) and vehicle-to-vehicle communication for transmitting traffic congestion events. Although these contributions build on the technology for cooperating vehicles, they are not intended to prevent congestion in advance (i.e. before congestion occurs) as our envisioned solution is.

In conclusion, although research on intelligent transportation systems has focused e.g. on traffic network planning,

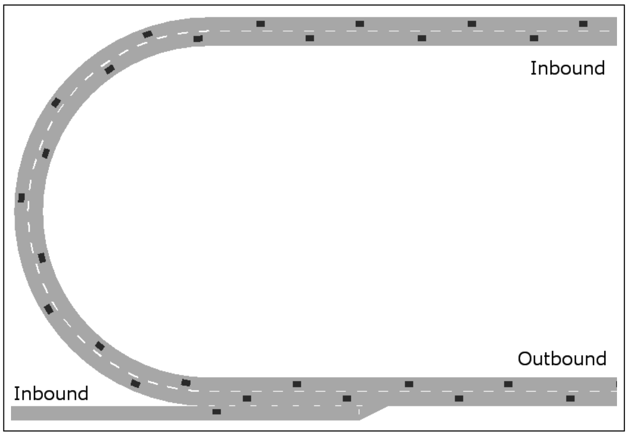


Figure 4: Exactly the same scenario as in fig. 3 except that the simulator was modified to support vehicles coordinating lane change with the vehicles on the main lane. (Notice the absence of congestion.)

on automated vehicle collision avoidance based on proximity sensors and vehicle cooperation, on traffic network congestion monitoring, on vehicle-to-vehicle wireless communication, and on autonomous vehicle navigation, to our knowledge there is no related work or publicly available vision on vehicle cooperation for preventing traffic congestion and in particular on preventing such congestion with the help of dynamic time-space corridors.

5. SUMMARY

We have described our vision of congestion-free road traffic using cooperating objects. In particular, cooperating vehicles are able to negotiate virtual vehicle slots needed for the whole of their passengers journey, i.e. from departure to arrival. These slots have guaranteed speed and safety distances to other slots and as such will not be overrun by other vehicles. Vehicles in these slots will not experience traffic congestion. Our vision includes the negotiation of the virtual slots at the consecutive lanes through which the vehicle needs to circulate and of parking space for the end of its journey. Cooperating vehicle and urban landscape objects provide support for such negotiation and thus enable our vision of congestion-free road traffic.

To the best of our knowledge, the concept of time-space corridors for vehicles is original. This concept was inspired by research on data communications protocols. Furthermore, we have described an innovative use of cooperating and sensing vehicles as we expect these to negotiate and establish congestion-free virtual slots. We expect that the implementation of this congestion-avoiding system will bring forward new challenges and technical progress. We also expect the social, economical, and environmental impact of deploying our envisioned system to be tremendous. Environmentally, we expect that without traffic congestion there will be less pollution on the roads. Economically and socially, we expect that people will spend less time commuting and in general be less stressed and more productive. Finally, we expect the deployment of our envisioned system to become a source of technical and economical development for the vehicle and telecom industry.

6. ACKNOWLEDGEMENTS

The author would like to thank the Sentient Future Competition for awarding this paper.

7. REFERENCES

[1] Japanese ITS AHR web site. http://www.ahsra.or.jp/, 2006.

[2] Japanese ITS VICS web site. http://www.its.go.jp/etcvics/vics/, 2006.

[3] US ITS New Initiatives' web site. http://www.its.dot.gov/, 2006.

[4] Web site of the road traffic simulator used in this paper. http://www.helbing.org/, 2006.

[5] M. Maekawa. ITS (Intelligent Transportation Systems) Solutions. *NEC Journal of Advanced Technology*, 2004.

[6] T. Sivaharan, G. Blair, A. Friday, M. Wu, H. Duran-Limon, P. Okanda, and C.-F. Sorensen. Cooperating sentient vehicles for next generation automobiles. *First International Workshop on Applications of Mobile Embedded Systems*, June 2004.

Ambient Intelligence by Collaborative Eye Tracking

Eiko Yoneki
University of Cambridge
Computer Laboratory
Cambridge CB3 0FD, UK
eiko.yoneki@cl.cam.ac.uk

ABSTRACT

A key aspect for the design of a future sentient computing application is providing ambient intelligence for non-expert users. Automatic, self-organizing and self-managing systems will be essential for such ubiquitous environments, where billions of computers are embedded in everyday life. Eye tracking provides information on both explicit and implicit subconscious social interactions and indicates directions when other communication is inappropriate. Integration of eye tracking and sentient technology will create a powerful paradigm to control and navigate applications. In a public setting, the aggregation of people's observations and knowledge provides a valuable asset. Ten years progress on sensor device hardware and software should realize this paradigm, and numerous applications can be integrated into this technology.

1. INTRODUCTION

We witness a rapid evolution in wireless devices and ubiquitous computing (aka ambient computing), with small computers becoming embedded throughout our environment. Wireless Sensor Networks (WSNs) are composed of multiple, interconnected nodes that are equipped with sensors, wireless communication transceivers, power supply units, and microcontrollers on chips of only a few millimeters square. The sensors are used to gather different types of data such as pictures, motion, sound, temperature, radioactivity, and pressure. In ten years, we imagine that more advanced sensors will appear and those sensors are able to capture 3D images from far distances with high accuracy. Sensors interconnect to establish multi-hop wireless networks streaming captured multimedia data. This heterogeneous collection of devices will interact with sensors and actuators embedded in our homes, offices and transportation systems, all of which will form an intelligent pervasive environment. People have to interact with invisible, ambient technology, which must be usable by non-experts. Thanks to Ambient Intelligence, the system will need less input from users and fewer mistakes will occur, because it will take note of the user's history and context and can make 'educated' guesses of the user's needs. Thus, the system will come up with suggestions and questions like 'I think you will need this', or 'Would you like me to adapt for this context?'

The vision of an activated world is action oriented, and, rather than dictated, it follows and enhances human behavior. The social implications are substantial. For example, is the person looking directly at you, to the ground or simply past you, showing interest or boredom, aggressiveness or submissiveness [14]? These habits form a powerful method of subtle communication. This new dimension of ubiquitous computing requires more complex communication mechanisms and, most importantly, intelligent processing of information collected from sensors. Network environments for ubiquitous computing will be highly decentralized, distributed over a multitude of different devices that can be dynamically networked and will interact in an event-driven mode.

This paper describes future ambient computing, where sentient applications are controlled and coordinated by human eye tracking in many different ways such as forming group communication, sequence of interactions, consensus of the next action, and so forth. Coordination of eye tracking can be between two people, between a person and an object, or among several people. Research requires extensive work with interactive robotics, computer vision, image recognition-understanding-generation, machine learning, data mining, as well as human behavioral studies and cognitive modeling. Ten years will give ample progress in these areas.

Eye (Gaze) tracking is an important human social skill. It is believed that the form of the human eye has evolved in such a way as to allow other humans to infer the direction of other people's view with ease [6]. Especially the high contrast between the sclera (the white part of the eye) and the iris is unusual and cannot be seen in this form in other species [9]. Eye tracking is used in explicit and implicit subconscious social interactions as well as to point and indicate directions when vocal communication is inappropriate. People can immediately recognize if their communication partner is looking at them or past them and infer characteristics of the partner such as interest, fear, or unease from it. Sensitive eye movements can act as a language of emotional states and therefore their detectability in visible light was an important gain in evolution. There are also numerous application fields of eye tracking and they can be grouped into two main tasks, point of interest detection and information transmission via eye movement, although spanning across these fields is common.

Determining attention focus is probably the most common use, although attention is not directly coupled with the line of sight. Point of interest information can be used in a multitude of applications of which marketing, psychophysical experiments, and verification of attention to critical situations such as traffic while driving [18] are the most common uses.

The second main area is to use movement as a direct channel of information, encoding bits as eye movement to the left or to the right. As this method has a relatively low bit rate, it is most often used if other methods of communication are no longer available. This case usually arises from medical conditions when patients have no voluntary control over large parts of their muscles, such as after penalization or with Amyotrophic Lateral Sclerosis (ALS) [2]. ALS for example is a degenerative neural disease causing total loss of muscle control, but sometimes before the terminal stage of locked-in syndrome, eye movement is still possible. For these people, a technical solution for communication via eye tracking can mean at least a little normality in an otherwise difficult situation [5, 11].

Applications combining these two are becoming increasingly popular, as they use point of interest detection as a way of controlling systems. This finer scale resolution allows for a higher bit rate and makes such systems susceptible to more advanced Human Computer Interaction (HCI) devices. For example, the military has used helmet-based eye tracking to act as an additional input and free the pilots' hands to perform other duties. Civilian applications of gaze-based HCIs exist as well, for example for video conferencing or civilian avionics. Furthermore, technical applications of gaze tracking would be necessary in artificial intelligence and social robotics. To mimic human behavior, a robot would have to be capable of reading the emotional language encoded in the movement of the eyes and the direction of gaze.

A significant amount of research literature exists on eye tracking, but most of the earlier approaches have required special hardware and have been to some extent invasive [1, 16, 10]. Those limitations have prevented widespread use of gaze tracking and the technique is currently only used in specialist areas. I envision that the evolution of wireless sensor hardware will overcome many limitations. Sensors will be able to capture 3D images from a distance.

This paper continues as follows: Section 2 describes key aspects of technologies supporting sentient applications using eye tracking. Section 3 describes examples of application scenarios demonstrating the idea and Section 4 contains conclusions.

2. TECHNOLOGY

Research in ubiquitous computing covers diverse research areas, including distributed system design, distributed robotics, wireless communication, signal processing, information theory, P2P networking, embedded systems, data mining, language technology, intelligent agents, and optical technologies. Capturing the eye movement by cameras is possible with current technology, and advanced sensors for this purpose will appear within ten years. The challenge is to capture them from a distant sensor location and establish efficient real-time operation of wireless sensor networks. Outdoors, aerial robots can be used to collect such data. We have the essential technology already and what is needed is to make it scalable, reliable and deployable.

2.1 Eye Tracking

The first eye tracking method was proposed in 1969 for visual targeting of weapon systems by aircraft pilots, allowing them to keep their hands free to control the plane [12]. The first device was built by the US military [13]. These devices exploit that a person's direction of gaze is directly related to the relative positions of the centre of their pupil. The accuracy of these systems depends largely on how precisely the relative positions of the pupil centre and the corneal reflection can be located. To locate the pupil accurately, early systems used a light source at the side of the user and camera with a semi-silvered mirror mounted at 45 degrees to reflect light from the source along the camera axis and into the eye of the operator. In 1989, an eye tracking device [7] was proposed which used a tiny infrared LED mounted in the center of an infra-red sensitive camera, eliminating the need for semi-silvered mirrors. In the more recent vision-based system, the tracking is performed by algorithmically analyzing images coming from video cameras. The use of IR LEDs and a cameras conferred the additional benefit of a lighting independent image. The most recent development is to use a purely vision-based approach. These systems use the natural illumination of the scene and record images with normal video cameras to infer gaze direction. The most popular algorithms have been neural networks to learn the mapping of small images of the eye to the 2D gaze direction. One of the first groups was Baluja et al. [3] at CMU in 1994. The work was continued by Stiefelhage and Waibe [20] and achieved a high accuracy of about 1.4–2.0 degrees using a standard back propagation algorithm on images of size 20 x 10. More recently, other labs have developed similar methods, Xu et al. [23], and application fields are expanding, such as attention tracking during meetings [19].

2.2 Progress of Sensor Hardware

Current research envisages a multitude of inexpensive cameras and projectors embedded in the environment. The cameras infer the geometry and reflective properties of the visible surfaces and the projectors create 3D imagery for a user whose eye positions are tracked in 3D. Current limitations include sensitivity of the camera and narrow fields of camera view, and only few people can be tracked. The cost of cameras and eye contact sensors will fall in ten years, and more sophisticated sensors with eye tracking capability will appear for highly detailed observation of eyes.

2.3 Ubiquitous Computing

The Internet and computer hardware/software made large scale distributed computing possible. The evolution of ubiquitous computing will make a change in a different dimension. Individual systems have to scale down to support ubiquity. Data from sensor networks need to provide pervasive access through a variety of wireless networks. There are inherent resource limitations in the technologies for processing, storage and communications (and power) in this context, and these lead to novel system performance requirements. A new platform needs to cover the range from tiny MEMS to Internet scale P2P systems and must include not only quantitative performance but also quality of service as a critical issue. A total system view will be based on information from a variety of heterogeneous sources and will require knowledge fusion; a reactive system between sensing, decision making and acting will be a common application feature. The architecture of global computing is a fine-grained, open, component-based structure that is highly configurable and self-adaptive. A difficult issue here is that current applications are tied to sensor deployments (see [22] for more details). A new type of open platform is required, where sensed data can be shared among different applications over large-scale environments. Data management over heterogeneous networks, computing, and social environments will be crucial.

Ubiquitous computing infrastructures require software technologies that enable ad hoc assemblies of devices to spontaneously form a coherent group of cooperating components. This is a challenge if the individual components are heterogeneous and have to engage in complex activity sequences to achieve a goal. Today, the interaction between the components of these environments is carefully designed by hand. Most sensor network applications are implemented as complex, low level programs that specify the behavior of individual sensor nodes. WSNs need to organize themselves from components built by different applications. Programming for WSNs raises two main issues; programming abstractions and programming support. The former focuses on providing programmers with abstractions of sensors and sensor data. The latter is providing additional runtime mechanisms that simplify program execution.

Context Awareness: Next-generation conference rooms are often designed to anticipate the new rich media presentation. Current research in high-end room systems often features a multiplicity of thin, bright display screens (both large and small), along with interactive whiteboards, robotic cameras, and smart remote conferencing systems. Smart spaces and interactive furniture design projects have shown systems embedded in tables, podiums, walls, chairs and even floors and lighting. Exploiting the capabilities of all these technologies in one room, however, is a daunting task. For example, faced with three or more display screens, all but a few presenters are likely to choose simply replicating the same image on all of them. Even more difficulty is the design challenge: how to choose which capabilities are vital to particular tasks, or for a particular room, or are well suited to a particular culture. The incorporation of media-rich engagement strategies in meetings creates a need to provide meeting participants with appropriate tools for managing these media. Research in areas such as context-aware computing, interactive furniture, and mobile devices is moving rapidly. People expect to find the adaptable ease of use that they get from their personal devices in all the technology they encounter.

2.4 Security

Wireless networks are becoming more pervasive and devices more programmable, thereby facilitating malicious and selfish behavior. A ubiquitous application may involve collaboration between ad hoc groups of members. New encounters occur and there are complex issues in knowing what entities to trust. Based on predefined trust, recommendations, risk evaluation and experience from past interactions, an entity may derive new trust metrics to use as the basis for authorization policies for access control (see SECURE project [4]). This raises serious concerns about privacy, surveillance and freedom of action. While providing location information can be a one-way system where the location providing tools do not track who is receiving, once your phone, PDA, or other device receive information, your location is potentially available to others. The design of the system will require multi-disciplinary efforts by technologists, social scientists, and societal observers.

3. APPLICATION SCENARIOS

There will be many different uses of the approach described in the previous sections. Several potential scenarios are described below. This list is not exhausted.

3.1 Intruder Detection

By using the correlation between gaze-direction and point of interest, it is possible to find an unobtrusive way of determining attention. This allows gathering the data while people continue their normal task unaware of monitoring, providing data of conscious and subconscious awareness in a natural environment. At an airport, for example, the sensors on the wall sense people's gaze movement. People notice any strange incident, other people's behavior, or objects unconsciously for ~ 0.000001 seconds. This information can be collected to use the detection of any security violation such as suspicious behavior of people or objects left alone.

3.2 Screen Navigation

The multiplicity of recent displays makes it difficult to control what should be shown on specific featured displays. This can be controlled through an eye tracking orchestrated interface. An eye tracking mechanism calculates the user's gaze direction and this can be used to control the volume of the soundtracks of the video streams either by increasing the volume of the selected stream, scaling the volumes by their spatial distance from the selected stream, or scaling the volumes by their temporal distance from the selected stream so the less recently selected streams are quieter. Gaze direction can also be used to identify the stream at which the user is looking and zoom in on it, following a time-out period. The centre of the user's attention can be drawn in higher detail than the rest of the picture by eye tracking in non-uniform rendering of images.

- You are at an airport lounge waiting for the gate assignment of the plane. When the plane delays, the rescheduled time could be in 10 minutes or in 1 hour. The flight schedule screen senses gazes, and when it gets high hits, it releases additional information on the screen or delivers information to the customer's mobile phone. Eyes are used to communicate with the tag on the screen.
- At the main plaza during a nice summer evening, people are watching a football game on a big screen. The screen zooming or selecting the angle are chosen based on the gaze movement of the audience. What is on the screen will thus reflect the interest of the majority of people.
- Interactive TV: sensors are embedded in the TV, which senses movement of gaze for navigation such as zooming or changing channels.

Rennison et al. [17] have worked on gestural navigation of multidimensional information space in 1995 at MIT Media lab. Figure 1 shows 3D Internet browsing navigated by hand gestures. The evolution of sensor networks since 1995 indicates that the next ten years will bring further dramatic progress in technology.

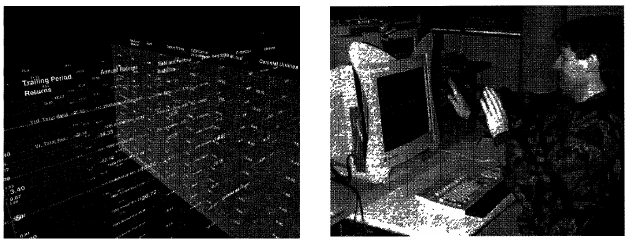


Figure 1: 3D Internet navigation by hand gesture (from [17])

3.3 Effective Video Conference

Video conferencing is a useful tool to conduct meetings without travel. One potential problem is that video conferencing does not necessarily support the regulation of conversational turn taking any better than telephony-based systems. In multiparty conversations, when the current speaker falls silent, it is not obvious who will be the next speaker. Previous research suggests that the looking behavior of conversational partners, or more specifically, their eye contact with each other, plays a critical role in determining who is to be the next speaker in group conversations [8, 21]. Using low cost eye tracking and measuring eye contacts among the participants could accurately provide more natural video conferencing. There has been an approach to solve this problem by setting multiple cameras, but using 3D image sensors with networking capability will make this even simpler and more effective.

3.4 Medical Applications

There are some medical conditions such as paraplegia, that make other, more traditional methods of communication increasingly difficult, or even impossible. For these patients, eye tracking devices could be a method of communication and improve their quality of life.

Another example is for patients with psychologically complex problems where logging eye tracking data for certain periods could help to find hidden mental problems.

3.5 Unsafe Driving Detection

Eye tracking by sensors detects unawareness of traffic conditions by the driver and offers the potential of improving safety by alerting the driver of tedious but potentially dangerous situations if not sufficient attention is given to the traffic.

3.6 Shop Assistance

Customers' gaze movements are captured to determine which colors of clothes their eyes are on, which types of DVD recorders their eyes are on, and how long their eyes are kept on those objects. The shop could assist the customers by showing more products of interest based on these observations. Furthermore, this information could be used for future improvement of the products or layout of the shop display.

4. CONCLUSTIONS

Automatic, self-organizing and self-managing systems will be essential for supporting ubiquitous environments, where billions of computers are embedded in everyday life. A key aspect to design a future sentient computing application is to provide ambient intelligence for non-expert users. Eye tracking provides explicit and implicit subconscious social interactions and indicates directions when other communication is inappropriate. Integration of eye tracking with sentient technology will create a new paradigm to control and navigate applications. In our society, there is information overload while people are not getting the information they need. They might not even know what exactly they want or need. In a public setting, the aggregation of people's observations and knowledge is a useful and important asset, which can be harvested without the conscious contribution of anybody. Using ambient intelligence, a consensus of knowledge can be obtained and used for good purpose without interfering with people. The applications proposed in this paper aim to construct ambient intelligence by eye tracking, providing ways of effectively coordinating humans, objects, and environments in invisible ways by sentient objects.

Acknowledgement: This research is funded by EPSRC (Engineering and Physical Sciences Research Council) under grant GR/557303. I thank Earl Rennison for showing his work (in 1995) and inspiring the proposed ideas and Jean Bacon (University of Cambridge) for providing helpful suggestions on wireless sensor networks.

5. REFERENCES

[1] A. S. Laboratories. http://www.a-s-l.com.

[2] Amyotrophic lateral sclerosis fact sheet. http://www.ninds.nih.gov/health_and_medical/pubs/als.htm

[3] Baluja, S et al. *Non-intrusive gaze tracking using artificial neural networks,* Technical Report CMU-CS-94-102, Computer Science Department, USA, 1994.

[4] Cahill, V. et al. *Using trust for secure collaboration in uncertain environments,* IEEE Pervasive Computing, 2(3): 52-61, 2003.

[5] Chapman, J.E. *Use of an eye-operated computer system in locked-in syndrome,* CSUN's International Conference: Technology and Persons with Disabilities, 1991.

[6] Emery, N. J. *The eyes have it: the neuroethology, function and evolution of social gaze,* Neuroscience and Biobehavioral Reviews, 2000.

[7] Hutchnson, T.E. *Eye Movement Detector*, U.S. Patent 4,836,670, 1989.

[8] Isaacs, E. et al. *What Video Can and Can't Do for Collaboration,* Proc. ACM Multimedia, 1993.

[9] Kobayashi, H. et al. *Unique morphology of the human eye,* Nature, 1997.

[10] L. Technologies. http://www.eyegaze.com.

[11] Majaranta, P. et al. *Twenty years of eye typing: systems and design issues,* Proc. ETRA, 2002.

[12] Mason, K. A. *Control Apparatus Sensitive to Eye Movement,* U.S. Patent 3,462,604, 1969.

[13] Merchant, J. et al. *A Remote Oculometer Permitting Head Movement,* Aerospace Medical Research Laboratory, WrightPatterson Air Force Base, AMRL-TR-73-69, 1973.

[14] Nummenmaa, T. *The language of the Face. University of Jyvaskyla Studies in Education*, Psychology and Social Research, 1964.

[15] Ramesh Raskar, G. et al. *The Office of the Future: A Unified Approach to Image-Based Modeling and Spatially Immersive Displays,* Proc. SIGGRAPH, 1998.

[16] S. Instruments. http://www.smi.de.

[17] Rennison, E. et al. *Issues of Gestural Navigation in Abstract Information Spaces,* ACM CHI Conference, 1995.

[18] Smith, M. et al. *Determining driver visual attention with one camera,* IEEE Transaction on Intelligent Transportation Systems, 2003.

[19] Stiefelhagen, R. *Tracking and Modeling Focus of Attention in Meetings,* PhD thesis, University of Karlsruhe, 2002.

[20] Stiefelhagen, R. et al. *Tracking eyes and monitoring eye gaze,* Proc. Workshop on Perceptual User Interfaces, 1997.

[21] Vertegaal, R. et al. *Effects of Gaze on Multiparty Mediated Communication,* Proc. Of Graphics Interface, 2000.

[22] Yoneki, E. and Bacon, J. *A Survey of Wireless Sensor Network Technologies: Research Trends and Middleware's Role,* Technical Report UCAM-CL-TR646, University of Cambridge, 2005.

[23] Xu, L.-Q. et al. *A novel approach to real-time non-intrusive gaze finding,* British Machine Vision Conf., 1998.

"A day in the life of a not too distant future" Sentient Future Competition

Phillip R De Caux
xposition
Hollyhock Cottage, Buttle Lane,
Shepton Beauchamp, Somerset, UK
+44 1460 249396
phildecaux@xposition.co.uk

ABSTRACT
In this paper, I try to envisage how the development and proliferation of embedded systems will affect normal daily life in 10 years or so.

Categories and Subject Descriptors
C.3 [**Special-purpose and application-based systems**]: Microprocessor/microcomputer applications, Process control systems, Real-time and embedded systems, Signal processing systems, Smartcards

General Terms
Performance, Design, Experimentation, Security, Human Factors, Theory.

Keywords
Sentient Future Competition, Embedded Systems, Fiction.

1. INTRODUCTION
Presented as an advertising feature, my vision illustrates some of the many advantages of an integrated life-work information and communication tool, the eLink™ (WiSIP/MAN) headset. The eLink™ operates efficiently and seamlessly within a wireless LAN/MAN environment and is fully compatible with complimentary systems such as route planning, home/small office automation, traffic control, transport routes and booking, financial transactions, and personal space protection.

The eLink™ headset uses the latest onboard encryption and Session Initiation Protocol (SIP) technology to provide a secure and robust performance which, coupled with a long-life rechargeable battery, amazing light weight and comfortable design, will complement and enhance daily life beyond what is imaginable using today's systems!

2. A DAY IN THE LIFE OF A NOT TOO DISTANT FUTURE
Hobz woke to the sound of a subdued, yet irresistible polyphonic cacophony. As his feet touched the carpet, the alarm clock, sensing his movement, curtailed its insistent racket and the radio came on to announce that yet more atrocities had been carried out in the name of world security.

His clothes lay in the same abandoned heap they had been left in the night before, and he cursed himself for not being more careful - now he would either have to wear a crumpled suit or, worse still, would have to wear the awful one that rarely made an entrance into the office. Now that he worked mainly from home, his suit collection had depleted somewhat.

Then he remembered that he had forgotten to 'phone Olivia - again! It hadn't helped that he had left his eLink™ off the base unit the night before and couldn't access his address book. It was only when he got home that the system had updated and recharged itself. Even though it was almost a valid excuse, when he tried contacting her the network could not find her. She was either out of range, or, more likely, he had been added to her "blacklist".

After showering, he selected the best of the bad suit options and got dressed. He then detached the fully-charged eLink™ from its base unit on his bedside cabinet and wound it around his ear. Immediately, he was informed there was a problem in the kitchen.

As he walked in, rather than the familiar scene of a prepared breakfast, instead the table was decidedly empty and an urgent bleeping was emanating from the info screen on his refrigerator. He had forgotten to approve the shopping order and so, to use a phrase his mother was fond of, the cupboard was bare. Perhaps he should set the system to "auto-order"; this was getting to be a habit!

Direction and deviation
Yet another pre-office visit to the extortionate breakfast bar beckoned! He added the detour into the autoSOHO™ and selected some food and drink from the menu that appeared on the screen. The eLink™ issued a comforting bleep to indicate that the route details had been transferred and, pausing only to pick up his rucksack, he left the flat. The door bleeped at him a couple of times and then the eLink™ let him know that the flat was secure. Hobz remembered when he used to rush around at the last minute trying to find his keys, invariably making him late and stressed - how times have changed!

En route, Hobz spoke the phrase “Harry - office” and the eLink™ responded with a connecting tone and, a few seconds later, Harry answered. Hobz let him know that he might be a bit late and got the low-down about the first meeting of the day. He could have made the journey with his eyes closed, the quiet voice in his ear telling him which direction to take, when to wait at a crossing and when to cross. Any potential collision with a fellow pedestrian or lamp post was pre-empted by a gentle warning from the optional Personal Space Protection System (PS2)™.

Expectation and transaction

He entered Penn's Coffee Bar and sat at a vacant stool at the bar. Within seconds, the assistant brought over his order, a bacon sandwich drowning in chili sauce with a huge, steaming cup of "builder's tea". Hobz thanked her profusely and started eating the delicious and, more than likely, toxic sandwich. Though incredibly bad for the majority of his organs, this was an excellent hangover cure! Once he had finished, the eLink™ prompted him to approve the bill. He pressed his index finger on the pad and, his identity confirmed, the payment was deducted from his account.

Expectation and transaction

He entered Penn's Coffee Bar and sat at a vacant stool at the bar. Within seconds, the assistant brought over his order, a bacon sandwich drowning in chili sauce with a huge, steaming cup of "builder's tea". Hobz thanked her profusely and started eating the delicious and, more than likely, toxic sandwich. Though incredibly bad for the majority of his organs, this was an excellent hangover cure! Once he had finished, the eLink™ prompted him to approve the bill. He pressed his index finger on the pad and, his identity confirmed, the payment was deducted from his account.

Safety and speed

Fifteen minutes later, completely refreshed, Hobz turned left, as suggested, into Broad Street and joined the crowd of people waiting to cross the road at the crossing point. He waited no more than ten seconds before the vehicles halted automatically to allow the mass to surge forward. He still found this disconcerting, but apparently accidents at crossings had been reduced by some amazing percentage.

A group of people, Hobz included, parted from the main pack and headed towards the underground. He walked through the e-stile, the voice in his ear informing him he had been charged five pounds for the privilege, and descended the escalator to the platforms below. Whilst directing him along the correct path to his platform, the voice informed him that the next train was due in two minutes and suggested he walk a little faster ...

3. ACKNOWLEDGMENTS

My thanks go to the tutors and students at Liverpool University and Laureate Online Education for inspiring me to write this paper and for helping me find the skills to be able to think about the future with a fresh outlook.

SPECIFICATION

Manufacturer/supplier	Deutsche Telekom
Model	eLink10™ (MAN[1]/WiSIP[2]) headset
Fitting	Ear hook design (left or right fitting)
Weight	10g
Headphone	Monaural, 18mW@16Ù (max)
Microphone	Miniature omni-directional electret condenser
User controls	Voice recognition, pressure sensitive pad
Security	Access via pFPM™ – partial fingerprint matching via built in pressure pad WEP/WPA + AES encryption
Power	Integrated/rechargeable Li-Poly battery Power management system offers up to 100 hours on standby and 4.5 hours continuous use
Standard services	Wireless/mobile telecommunications (SIP) Metropolitan Navigation overlaying Satellite Navigation (ManNav over Sat-Nav)
Standard additional equipment	eLink docking station including recharging unit and LAN
Optional services/ equipment	Personal Space Protection System (PS^2)™ eTransact™ interface, autoSOHO™ interface, RSSAnnounce™, tLink™ interface, recharging unit

Please note that any trademarks are for effect only and are not designed to imply any actual legal standing

Figure 1: Possible specification for the eLink10 system

Sentient Future Competition: Embedded WiSeNts & Agnostic Algorithms of Creation

Panagiotis Bairaktaris
Bsc Student in Computer Science,
City University, London, UK
42, Abbott's Park Road
E10 6HX Leyton, London
++44 (0) 7913 1712245
panos95@yahoo.com

ABSTRACT
...explore the possibilities of interference among two distinct but almost identical dimensions by letting things that happening in the virtual world to reflect themselves in reality....

1. INTRODUCTION
It is a lazy Sunday afternoon after a long Saturday night… and here I am, sitting on a bench in Hyde Park. '…a quiet evening… after a crazy party night is well deserved…' were my thoughts whilst looking at the people rollerblading around the lake. Suddenly I hear my mobile's ringing; it is Dennis, my friend from the University. I was wondering how he was doing – a little hungover maybe?

-Hey mate, how are you? Are you all right?

-Yeah man, I'm fine, I was just checking out our new assignment *`Parallel Environments within Divine and Agnostic Algorithms of Creation…`* I thought I should call you 'cause … man- it really doesn't make any sense…

-Hmm…well, emm…maybe not now…I'm about to lay flat on the grass in Hyde Park, enjoying the sunshine…

-Hey, don't feel pressured – but we have to do it by the end of next week – so you might want to have a look at this and then talk about it. C'mon, you don't have to leave the park – you know that…

-Alright – just a moment…

2. WHAT IS ALL ABOUT?

2.1 Mobile reality
I plugged into my mobile the new pair of sunglasses I bought the summer I was in Greece. No fancy stuff – just a nice pair, good enough for the morning after party – not to mention you don't look stupid when you're 'out there' – in your mobile's cyberspace.

The afternoon sunshine got a bit blurred and darkened, and then gave its place to a rapidly progressive appearance of a 3D environment. The sound of the people around me got mixed with some electronic interference from the small headphones embedded in my sunglasses. The lenses from outside were looking like normal lenses – sub-mirroring the environment- but there was always an option to project a message like *'don't bother me please'* or *'I 'm not here but I still can see you'*. Not my liking though – especially when cyber-communicating in a public place. Too much information – don't want to.

But the best thing about these sunglasses is that you don't have to worry about energy – no batteries needed – but that's because they are sunglasses, if you know what I mean!

Dennis was sitting in his armchair in front of the computer, as I was appearing in his cyber-room – an identical representation of his actual room, in Muswell Hill.

The environment resolution was absolutely faultless – no flickering or distorted angles. Mobile graphic cards have been evolved since I got my first mobile with a coloured screen– almost 10 years ago. He was looking like he'd just woken up – which he had. I was looking exactly like how I left from home this morning – last time I looked at myself in the mirror just before I went out of house.

2.2 Recently updated by mirror
The mirror in my house is one of the latest models. Too many settings – although it can do lots of things – if you want or need them of course. Every time you look at yourself in this mirror the databank in the central house computer is updated with the current image of yours – describing how you look and what you wore – and not only that: Through the mirror you can see past states of yours, i.e. how you were looking yesterday or last week, or even fiction ones, i.e. with this or that kind of t-shirt, jacket.

Our university project is the replication of our everyday life, created and modelled in a computer system in the form of a video game– the aim is to explore variations of *'decisions that have been already taken and actions that have already been done'* – that means that my everyday mirror image is well being used. Of course in the cyber mobile space you could appear as you like – but people tend to use this option only when they are participating in cyber communities. In normal everyday life, when there is a need for mobile 3D contact – from people who are using the technology for working, or studying, or meeting up with someone who is far away – they prefer to act like themselves. In police stations and the cyber-courtroom for instance, this is required by law; you can't enter the virtual room if you're not who you're supposed to be.

By the time I appeared to Dennis's room, he was typing something on the computer. He was actually doing this on real time in his place – what I was seeing was the result of his key-tapping actions as they were captured by his keyboard – and then processed in a way to reproduce the actual move of his hands on the keypad. The combination of the data that his computer was receiving from the Internet plus the on-time calculation of the moving 3D model of himself plus the representation of his room on the house central database, all these were being transmitted through his mobile, routed through one of the many wireless broadband network nodes around the city, and finally finding their way up to my mobile handset. In the same time, my holographic –recently updated by mirror- picture of me was sent back to Dennis's virtual mobile reality -equipped with the latest human-body modelling movement application- which was enhanced for both me and Dennis with the data that our clothes were producing in real-time according to our movements. The speech, image and body movement synchronisation is amazing – due to the high-detailed and powerful multi-dimensional graphics libraries that are available nowadays for free – so every virtual mobile can download and use.

2.2 Where everything comes from

All this were able to be realised by a combination of *Embedded WiSeNts*, a widespread mini-electronic computer technology that enables 'Cooperating Embedded Systems for Exploration and Control featuring Wireless Sensor Networks'.

These super-nano microchips are almost everywhere, in every kind of hi-tech or house equipment, in every pack of consumable product, in every clothing brand, even in things like the litter tray of a cat or the rubbish bin. They have changed drastically all aspects of life – even when machines are not involved, like relationships and beliefs.

First it was simple things like automated switch-controllers or small product-information data containers - they could be read with appropriate equipment but rapidly they evolved and acted wirelessly, transmitting data of the state of the object, most of the times using power sources such as heat or movement. Functions and information of things like the house-hold equipment, alarms, hi-fi, lights and heating are already easily accessible wireless from your mobile where ever you are – when ever you want. It's been quite a long time since you worried about leaving the light on, or the tap is leaking and you're on the beach in the Seychelles. Every new house is required to have a central network infrastructure which can be controlled externally by your computer and your mobile if you like – and these little things can interconnect with it. You can't get a building license otherwise. New ethical and operational issues rose by this – who has the password, who is the admin of the house, (me or my girlfriend?), and what if more than one person has main access to control things from far? And what about if my mobile is stolen? Does this mean that a complete stranger can have fun by changing the TV channels whilst I'm watching my favorite show?

2.3 Don't worry, this is history now

Reliable mobile phone speech recognition and other biometric safety measures are too much of a hassle to try to bypass – there are always loop-holes and back-doors but they are mostly virtual and anyway, most of the people have their iconic electronic world tailored as they wish – not as it is in reality. The same amount of difficulty applies for people to break through your temporary virtual world as if they wanted to make phone calls using your number without having your sim card.

2.4 A simple fact

But in the case of Dennis and me and our project, we wanted a model of our lives as real as possible, so that we'll be able to feed it with slightly modified actual data of our everyday life – just to study and research how the personal decision factor relates with a pseudo-random model of chance and choices when applied in the deterministic universe of our computers. That way we thought that we would explore the possibilities of interference among two distinct but almost identical dimensions by letting things that happening in the virtual world to reflect themselves in reality. In other words, we were dealing with the simple fact that we will never be sure for the state of specific material things that their exact representation existed also in our virtual world and vice-versa –unless we develop a way of maintaining our parallel but overlapping lives in some kind of order, something which is rather unlikely to happen!

2.5 Virtual Expo

To achieve this, we used transmissions of these Embedded WiSeNts that exist in our everyday life objects, to create a replica of our personal spaces. By calculating angles and distances of their position – plus the information provided by the industry design specifications - like the kind of object and its purpose & functionality- we ended up with a practically identical virtual interface that simulates our actual environment in bits and bytes. Our aim is to study the possibility to create the first virtual work environment, a work model that will be adopted by the most advanced and innovative hi-tech industries and not only. Our vision included small internet enterprises selling goods or services to update their web sites by introducing links to virtual halls, where their products will be demonstrated by several plugged-in employers or in many cases by just fictional avatars. No need any more for special designed 3D object libraries – since the Embedded WiSeNts chips allow every existing object to have its holographic representation already encoded and ready to be extracted and used any time.

It is as simple as this: You just need a database with your products – and your small virtual expo can be set up in minutes. Every change in your stock can be reflected immediately, and if you have a real hall that goods are demonstrated in shelves, the actual hall itself can be reproduced and be displayed and updated on request.

2.6 A day in the office

Anyone knows that a day in the office today is not as it was in the past...Working from home or from afar has been a reality for many years now, but in our model, you don't have to go to the office and you don't have to log in and use the server if you are urgently needed– you just have to plug your self in the office. There are of course rules that have to be followed: Every employer has to visit the same virtual office. Only small changes to your personal work space are allowed – just like in real life. The reason for this is that people's avatars are interacting in a virtual space that is created by data continuously transmitted by the *Embedded WiSeNts* existing in the actual environment. That means that the report you just printed on your virtual cyber office in this new laser jet, it will be printed in exactly the same laser jet in the real office (if it exists such a thing like a real office) – and if there were a paper jam, you would be able to see it– and in more advanced versions to fix it - only of course if you're wearing clothes (or something similar) and you're not laying naked on the bed or elsewhere...

2.7 Dressing code

Because clothing is a very important aspect of life, and *Embedded WiSeNts* have changed the way we are considering them. If someone were watching me now – as I am sitting on this bench in Hyde Park – he could see a guy making funny gestures with his hand – this is because I am checking out some CDs Dennis has on his shelves. As my hands are moving, my jacket detects the movement of my arms and wrists, communicates them to my mobile, which is responsible to generate their representation. This happens with my trousers and my shoes of course – I only need to enable one option.

2.8 Lock or unlock

From day one they became widely accepted and used, these *Embedded WiSeNts* have added unlimited new possibilities in everyday life, and not only in the virtual world. Everything is interconnected and can be controlled from a distance with your mobile. You can lock or unlock your chest of drawers if you want whilst you're on the bus – it all depends if you want your boyfriend to find your diary or your girlfriend to find your hidden telephone agenda...

2.9 The best thing

There are so many different ways that these widgets are being used, that it is impossible to count them all...For example, have you ever seen these days a queue at the supermarket till? No, of course not – people that go to super markets don't have to search for goods in the shelves – they just let themselves be guided by these fancy new trolleys embedded with *WiSeNTs* to find the shelf they want – and then, all they have to do then is to fill the trolley up with the goods and then head for the exit – as every product package contains microchips that communicate with the exits' sensors, charging your card with the appropriate amount of money. No place for queues here in our hectic city life - no way also to bypass the supermarket entrance or exit if you don't have the right wise card...And the best thing of all is that the trolley comes back to the super market alone!

Other uses: Bins that are full informing bin men to pick them up, maps providing updated information for countries you select by just touching them, keys that can be reprogrammed to fit another lock, drink bottles and medicine or food packages informing you about the expire day or improper storing conditions etc. Want to have some fun? You can be a master in role playing, adventures or strategy games, but playing a game with your environment as a game level – this is something different… Imagine: Play well, play smart, gain lots of points or do the hack, and a new mission will appear on your screen – a secret level - a hidden easter egg – sent it to your friends to see if they dare to challenge you in your place! Everything interacts within and with 'out there'. From the simplest operation to the extreme one – everything can interfere with everything – as long there is some *Embedded WiSeNts* hidden somewhere.

And you don't need to be a computer geek to handle all that...Household & hi-fi equipment with *Embedded WiSeNts* are designed to wirelessly cooperate and communicate with no-need of a central computer –although if there is one, one can set up things like the parallel interactive virtual environment as we've done. If you don't need one – or you don't have time, don't worry. Every refrigerator or every microwave that respects itself have the ability to change a TV channel, open the door, pump up the volume or change radio stations at any time. Accordingly, you can observe the progress of your nice dinner burning in the oven– chicken with roast potatoes that you are preparing to impress her- whilst watching your favorite football match drinking beer on the sofa in the lounge. Just choose the right channel or press the right buttons or give the right order, and a yummy (at least most of the time) picture (plus information about the state of the cooking), will appear in your plasma screen, in your mobile TFT, or even in these new sunglasses from this tourist trap in the Greek islands.

2.10 The difference

As for the geeks like me and my friend Dennis, most discussed 3D-WebCam technologies have found a way through our personal space with the real excuse to model our life through a matrix of ultimately perplexed trigonometric equations and game design technology. Patch it up with a broad-band connection and your mobile cyber-space is more than a reality...It's really in our hands to decide to live in one or two or more identical or alternate realities.

And the difference between virtual and real world?...Well, it can be as big as living a secret life inside the real and a real life inside the virtual – or the opposite perhaps - and as small as the difference between the open window in our cyber-room - but with the same one being closed in reality…

3. THE ASSIGNMENT

-Are you finished with the CDs?

Dennis's voice produced colored sound waveforms in the CD's surface I was looking at – and his words started trailing in the CD label: 'C'mon let's check this thing...It seems quite interesting...'

I floated near the arm chair and had a look on his screen.

The assignment description was wide open in a new window so we started reading.

<< -- ***Parallel Environments within Divine and Agnostic Algorithms of Creation*** --

Model and create a new environment using the Earth libraries we provide - minus the historical and contemporary ethical and philosophical classes.

With the use of evolution algorithms, and by fast forwarding them for time and space complexity aspects, simulate genetical transformations, aiming the creation of intelligence within the system. You are expected to experiment with the parameters until the creation of viable and self contained entities (who will have the power to interact intellectually between themselves and their environment) are created. From the moment of creation and afterwards you should observe the behaviour of those entities but you are not allowed to interfere.

Your objective is to be God, and you'll achieve this if the entities created develop analytical and philosophical qualities in the amount that they will start wondering from where and for what they' re created for. Full marks will be granted if a form of technological advance is achieved by the entities. If this happens, as a bonus you are allowed to include in your project the full version of ***Embedded WiSeNts*** *libraries – such this will ease the way of your entities to upgrade themselves the best way is possible in their future...>>*

4. APPENDIX

A.1 Introduction

A.2 What Is All About

A.2.1 Mobile reality

A.2.2 Where everything comes from

A.2.3 Don't worry, this is history now

A.2.4 A simple fact

A.2.5 Virtual Expo

A.2.6 A day in the office

A.2.7 Dressing code

A.2.8 Lock or unlock

A.2.9 The best thing

A.2.10 The difference

A.3 The Assignment

5. ACKNOWLEDGMENTS

Many special thanks to Mrs. Helen Georghiou for the grammatical, linguistic, and any other kind of support she has ever provided to me with her unique way, and to Mr. Dennis Korobov for the inspiration and feedback through our endless conversations. Special thanks to City University, London, UK, for its value as an unlimited resource of knowledge.

6. RELATED BIBLIOGRAPHY

Michael J. Kearns , Robert E. Schapire , Linda M. Sellie, “Toward Efficient Agnostic Learning, Machine Learning”, v.17 n.2-3, p.115-141, Nov./Dec. 1994.

Goldman, S. A., Kwek, S. S., and Scott, S. D. 2001. “Agnostic learning of geometric patterns”, J. Comput. Syst. Sci. 62, 1 (Feb. 2001), p. 123-151.

P. Sharma, S.-J. Lee, J. Brassil, and K. G. Shin, "Handheld routers: Intelligent bandwidth aggregation for mobile collaborating communities," HP Laboratories, Technical Report HPL-2003.

Mountain, D. and Liarokapis, F. 2005, “Interacting with virtual reality scenes on mobile devices”, In Proceedings of the 7th international Conference on Human Computer interaction with Mobile Devices &Amp; Services (Salzburg, Austria, September 19 - 22, 2005). MobileHCI '05, vol. 111. ACM Press, New York, NY, 331-332.

G.Mair, J. Clark, R. Fryer, R. Hardiman, D. McGregor, A. Retik, N. Retik, K. Revie, “Hybrid virtual reality and telepresence utilising mobile phone technology”, Proceedings of SPIE, Telemanipulator and Telepresence Technologies V, Boston, Massachusetts, 4-5 November 1998. pp 60 - 70. ISSN 0277-786X, ISBN 0-8194-2985-6.

Kallio, S., Kela, J. and Mantyjarvi, J. (2003), “Online Gesture Recognition System for Mobile Interaction.” , IEEE International Conference on Systems Man and Cybernetics, 3, 2070--2076.

Stefani, O., Hoffmann, H., Patel, H., & Haselberger, F. “Pi-casso: Mobile Virtual Reality at office workplaces”, Accepted for the proceedings of Computer Graphics and Computer Imaging, 2004.

Sentient Future Competition: Father in Womb

T. Camilo, A. Rodrigues, J. Sá Silva, F. Boavida
University of Coimbra
Dep. of Informatics Engineering
Pólo II, Pinhal de Marrocos,
3030-290 Coimbra, Portugal
+351 239 790 000
{tandre, arod, sasilva, boavida}@dei.uc.pt

E. Sá
Superior Institute of Applied Psychology
Rua Jardim do Tabaco, 34,
1149 - 041 Lisboa, Portugal
+351 218 811 700
eduardosa@netcabo.pt

ABSTRACT
The pregnancy is a differentiated phenomenon in the couple's life. Nowadays, the man tends to participate actively even more in this process. The main idea of this application is to transport some of the mother's experiences as a pregnancy woman (e.g. embryo movements), to her partner, the father. This paper presents the concept *Father in Womb*, which enables the father to follow the embryo growth, movements and sensations, providing mechanisms for interaction between both.

Categories and Subject Descriptors
H.1.2 [**Model and Principles**]: User/Machine Systems

General Terms
Design, Human Factors.

Keywords
Wireless Sensor Networks, Human interaction.

1. INTRODUCTION

Nowadays, more and more new technologies are being available to the final user, which gladly, absorbs the potentials of each new gadget. Wireless Sensor Networks (WSNs) are one of these technologies that will be generalized in future years. These networks are composed by numerous and very small sensors, which present several specific constraints, such as energy, memory and processing limitations, offering a huge range of applications.

Health monitoring is one of the most important applications of WSNs, since they can be used to both sense health problems such as heart diseases, helping to save lives, and allowing new forms of communication between living beings. This document presents the concept "Father in Womb", which was submitted to the Sentient Future Competition organized by Embedded WiSeNts project [1]. This concept allows the father to become more involved with his son from his first months on the mother's womb. Nowadays only women can really feel and interact with their embryos; the father's role is only to follow the physical and emotional changes of the mother. He can not interact with the embryo, feel their changes, their movements and their "life".

The remainder of this paper is organized as follows: section 2 presents the main concepts behind "Father in Womb" idea; it explores the principal mechanism that can be applied so that father and embryo start to be more interactive. Section 3 presents the main requirements of the communication technology Conclusions are presented in the last section, Section 4.

2. RELATED WORK

Research and development of WSNs technology has been a collective effort linking university research centers, industry labs and government agencies, through a final goal: to build an architecture that enables WSN to become an accessible technology.

Nowadays there are no relevant projects that study the integration of WSN inside human body. However, in the area of monitoring healthcare there are several projects that intend to integrate this technology to support medical assistance. This integration provides new tools to help doctors on their work, such as augmenting data collection and real-time response, wherever the patience and doctors are. Patients will also benefit from this integration, since they will no longer be forced to stay in hospital beds (just because the monitoring machinery is static) and to regularly visit the doctors to report experienced symptoms, problems and conditions. With the integration of WSNs in these systems, patients will increase their mobility, due to the wireless capability of such nodes. The smart homecare architecture [2] is an example of such work, where the WSNs are used to collect data according to a physician's disclaimers, removing some of the cognitive load from the patient and providing a continuous record to assist diagnosis. This architecture integrates several elements, such as a real-time, long-term, remote monitoring and miniature wearable sensors. The authors claim that the integration with existing medical practices and technology can be used to provide assistance to the elderly and chronic patients. The SenseWear system, presented by Andre and Teller [3], is a set of wearable tools that are used to perform health monitor. The SenseWear Armb is an example of such a tool. It senses acceleration, heat flux, galvanic skin response and temperature. It has the ability to record all the data for later presentation and analysis. The applicability of these set of tools are among others: the study of sleep behaviors, competitive sailing, human-computer interactions and stress response in car and tank drivers. They can also be applied into any human, from children to old persons.

3. FATHER/EMBRYO INTERACTION

The mother's perception of the embryo's movements is considered one of the greatest landmarks during pregnancy, since it represents the first real perception of the embryo from the mother's point of view. Therefore, it increases the expectations referring to the future child. It is from the embryo's movements that the mother starts to distinguish the temperament attributes of the baby, besides it is the period when the interaction (mother/embryo) starts to be reciprocal. With this interaction it is possible to start understanding the baby's messages.

Nowadays, it is common to find men seated in the waiting room of the doctor's office, following their pregnancy wives to common medical attendances. This enforces the perception that men need to become even more integrated in the grow and in the birth of their future child. The gestation can and must be lived by the parents, as a couple.

During gestation, we observe physical and emotional adaptations both in women and men. It is not rare to find physical changes in the partner of pregnant women, as the increase of weight. An example of such conduct is the behavior of husbands in a tribe of Nova Guiné that, after the childbirth of his wives, stand lie down in bed as their women, presenting the same symptoms, as pain, discomfort, unreliability, depression and anxiety.

The technical idea behind *Father in Womb* is to deploy a WSN in the embryo premises. These sensors will monitor all the embryo activities, movement, sounds, images, temperature, heart beat, etc; helping the father to percept the behavior of his future baby. The WSN embryo will provide information with an actuator sensor network deployed in father body. The father will held several sensors (actuators) that will actuate according to the signals provided by the behavior of the embryo (Figure 1).

There are several embryo's movements that can be easily monitored, for instance the first hand or feet movements. But as the embryo grows up, the periodicity of movements will increase, as also the force applied, helping even more the monitoring.

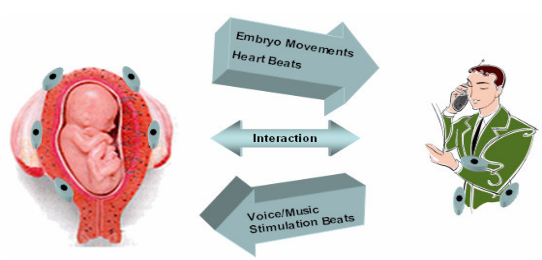


Figure 1- Sensor interaction between the father and the embryo

As the embryo gets bigger, new aspects can be introduced in the application, since the baby starts to react to external stimulations, as light and music, and also understands the physical sounds of the mother, for example her heart beating. With this in mind, *Father in Womb* application intends also to incorporate some mechanisms that allow the father to communicate with his future child, such as a movement actuator that touches the embryo hand.

One of the most important embryo's movements occurs during the 7^{th} month. In this month the baby's body is yet to short, and starts assuming a more comfortable position by turning his head upside-down, which will keep until the moment of the birth. This moment can also be monitored with our application. The father will know that the baby is performing accordantly to normal behavior.

In the family perspective the pregnancy is a delicate moment, since the women's body starts to change, the standard family behavior changes to new rhythms, the couple relationship can suffer slight revolutions and older brothers can feel jealousies. With the introduction of this application it is possible to minimize these kinds of problems, by allowing the father (or any other family element) to understand the women's behavior, due to a better share of embryo's relationship

4. CONCLUSION

In this document a new concept was presented, where the father is allowed to follow the embryo's life. *Father in Womb* permits the interaction between the parent and his future child, by exchanging sensations such as voice, movement and heart beats. With the possibility to create such an interaction, the women's gestation can become even more a mutual experience, where fathers stand for a more participate role in the embryo's life.

5. ACKNOWLEDGMENTS

The work presented in this paper is partially financed by the European project E-NEXT FP6 NoE.

6. REFERENCES

[1] Embedded WiSeNts project, http://www.embedded-wisents.org/index.html, January 2006.

[2] J. A. Stankovic, Q. Cao, T. Doan, L. Fang, Z. He, R. Kiran, S. Lin, S. Son, R. Stoleru, A. Wood, "Wireless Sensor Networks for In-Home Healthcare: Potential and Challenges", Workshop on High Confidence Medical Devices Software and Systems (HCMDSS), 2005

[3] D. Andre, A. Teller, "Health. Care. Anywhere. Today", Future of Health Technology-2, IOS, 2005.

LocuSent – large scale locust control system
Project submitted to the Sentient Future Competition

Milo Lavén
Architect MSA, Independent designer
Parmmätargatan 9
112 24 Stockholm, Sweden
+46 70 4385812
milolaven@gmail.com

ABSTRACT

LocuSent is a proposal for a massive monitor and control system for the desert locust. It's an extensive sensor network system that can survey vast and remote areas in order to prevent outbreaks and thereby prevent the terrible famine and the disastrous economical losses that follows in the trail of the locust.

1. INTRODUCTION

Locust is the name given to the swarming phase of short-horned grasshoppers of the family Acrididae. The origins and apparent extinction of certain species of locust—some of which reach 15 cm in length—are unclear. There are species that can breed rapidly under suitable conditions and subsequently become gregarious and migratory. They form bands as nymphs and swarms as adults both of which travel great distances during which they can strip fields rapidly and in so doing greatly damage crop yields. An exacerbating factor in the damage to crops caused by locusts is their ability to adapt to eating almost any food plant.

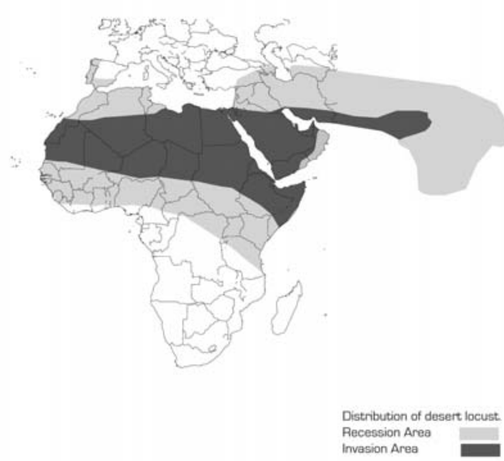
2. DESERT LOCUST

Plagues of desert locust, Schistocerca gregaria, have been recognized as a threat to agricultural production in Africa and western Asia for thousands of years. Locust scourges are referred to in the Christian Bible and the Islamic Koran. In some places, locust plagues have been held responsible for epidemics of human pathogens, such as cholera (this is because of the massive quantities of decomposing locust cadavers that would accumulate on beaches after swarms flew out to sea and drowned). Published accounts of locust invasions in North Africa date back to about AD 811. Since then, it is known that desert locust plagues have occurred sporadically up until the present.

Normally, the desert locust is a solitary insect that occurs in desert and scrub regions of northern Africa, the Sahel (region including the countries of Burkina Faso, Chad, Mali, Mauritania, and Niger), the Arabian Peninsula (e.g., Saudi Arabia, Yemen, Oman), and parts of Asia including western India. During the solitary phase (yellow area on map), locust populations are low and present no economic threat. After periods of drought, when vegetation flushes occur in major desert locust breeding areas (e.g., India/Pakistan border), rapid population build-ups and competition for food occasionally result in a transformation from solitary behaviour to gregarious behaviour on a regional scale (red area on map). Following this transformation, which can occur over two or three generations locusts often form dense bands of flightless nymphs and swarms of winged adults that can devastate agricultural areas.

Desert locusts can consume the approximate equivalent of their body mass each day (2 g) in green vegetation: leaves, flowers, bark, stems, fruit, and seeds. Nearly all crops, and non crop plants, are at risk, including millet, rice, maize, sorghum, sugarcane, barley, cotton, fruit trees, date palm, vegetables, rangeland grasses, acacia, pines, and banana. Crop loss as a result of desert locust infestation is difficult to characterize, but it will be important for developing intervention strategies on a demonstrably cost-effective basis.

In 2004, West Africa faced the largest desert locust outbreak in 15 years. The costs of fighting this outbreak have been estimated to have exceeded US$60 million and harvest losses were valued at up to US$2.5 billion which had disastrous effects on the food security situation in West Africa. The countries affected by the 2004 outbreak were Algeria; Burkina Faso; the Canary Islands; Cape Verde; Chad; Egypt; The Gambia; Guinea; Libyan Arab Jamahiriya; Mali; Mauritania; Morocco; Saudi Arabia; Senegal; Sudan; Tunisia; Yemen and it was one of the main factors contributing to the famine in Niger.



3. MONITORING AND CONTROLLING

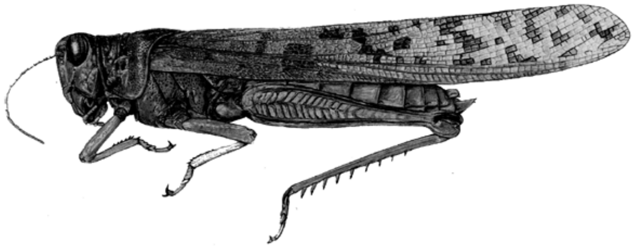
Monitoring locust populations during recession periods to anticipate the onset of gregarious behavior and to locate locust bands and swarms for control operations during outbreaks and plagues is a difficult task that has become increasingly technologically sophisticated. Model-generated forecasts of locust population events and general patterns of swarm movement during outbreaks and plagues are attempted using weather and vegetation index information gathered from satellite platforms, meso-scale and synoptic-scale weather patterns, soil mapping, and probabilities based upon historical knowledge about locust population dynamics throughout the recession and plague distributions. Though useful, these tools are not always accurate or timely.

Despite the existence of such elaborate technology for roughly guiding locust scouts, the discovery of locust bands and swarms is accomplished through visual and audio surveillance.

Comparatively effective, quick-to-apply and cheap control methods became available in the late 1950s which were based on persistent organochlorine pesticides like dieldrin. These were discontinued when it became clear that they posed unacceptable risks to human health and the environment. The current methods require that pesticides are applied in a more precise manner directly onto locusts. This means more resources are needed to locate and treat infestations. At present the primary method of controlling desert locust swarms is with organophosphate insecticides applied in small concentrated doses by vehicle-mounted and aerial sprayers. The insecticide must be applied directly to the insects.

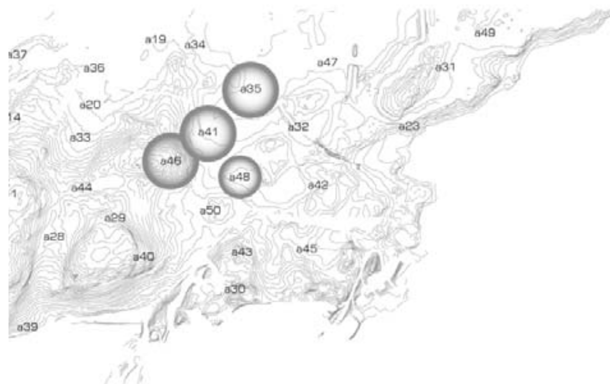
3.1 Detection by sound

Grasshoppers, locusts, crickets and katydids belong to a group of insects known as orthopterans (meaning 'straight wings'). One of the most recognisable features of this group is their ability to produce sounds by rubbing together certain parts of their body. This is known as stridulation. Usually only the males sing to attract females but, in a few species, the female also produces sound. Grasshoppers and locusts have a row of pegs like a comb on their back legs. They scrape these pegs against the hard edges of the front wings to make sounds.Experts are able to identify the different species of grasshopper by the sound they make. Since each species has a slightly different arrangement of pegs on their legs, the sound they make is unique. It's therefore possible to distinguish the desert locust from other grasshoppers and insects by their sound only.

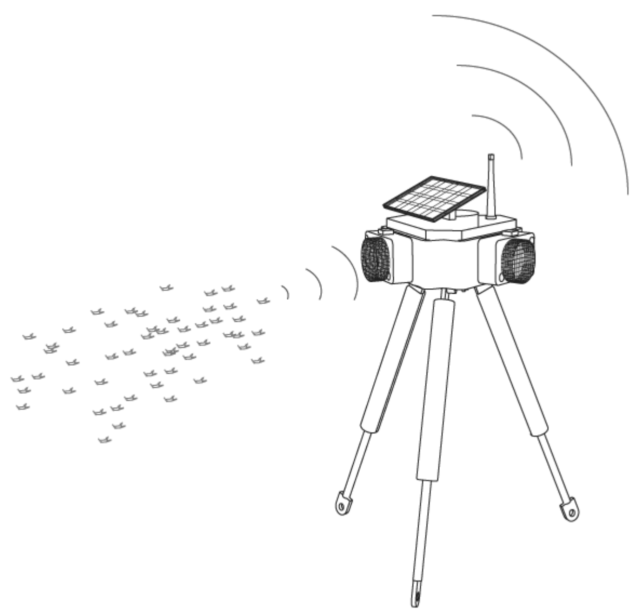


4. LOCUSENT

The LocuSent is triggered by the unique sound of the desert locust. Its sensors are set to detect the specific sound frequency produced by the stridulation of a swarm. Once it detects a swarm, it reports its id-number and position to a central monitor system.



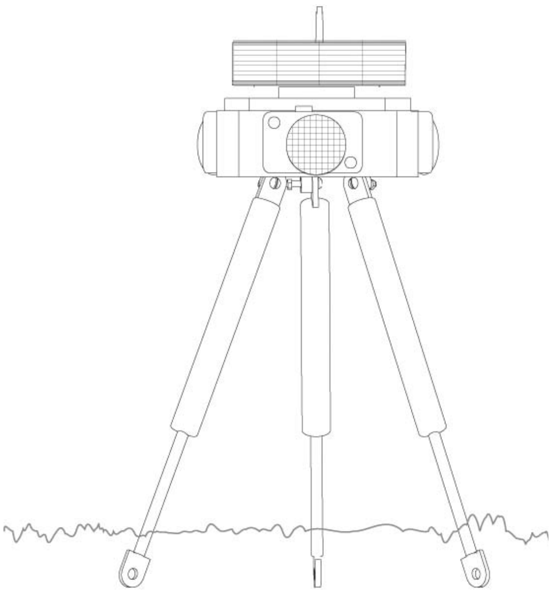
The desert locust is a difficult pest to control, and control measures are made more difficult by the large and often remote areas (16-30 million sq. km) where locusts can be found. Undeveloped basic infrastructure in some affected countries, limited resources for locust monitoring and control and political turmoil within and between affected countries further reduce the capacity of a country to prevent swarms.



By placing large quantities of LocuSents in the affected areas, and making an extensive network of self-sustained monitor sensors that communicates with each others as well with a central monitor system, it would be possible to map the desert locust and prevent outbreaks. Once the sensors detects the sound of a bigger swarm of the desert locust, the LocuSent reports its id-number and its location to the surrounding LocuSents and to the central monitor system.

4.1 Design

The design in this proposal is a tripod model which is placed manually by jeeps, helicopters or small airplanes. The unit contains antenna, solar panel, GPS, transmitter, receiver and sonar sensors. It is also possible to make smaller, more simple and robust units that can be dropped from the air without having to land.

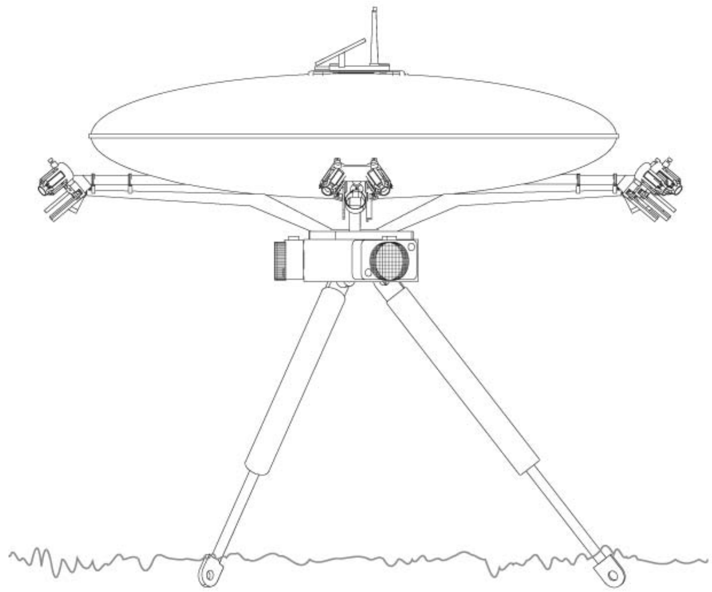


LocuSent monitor unit

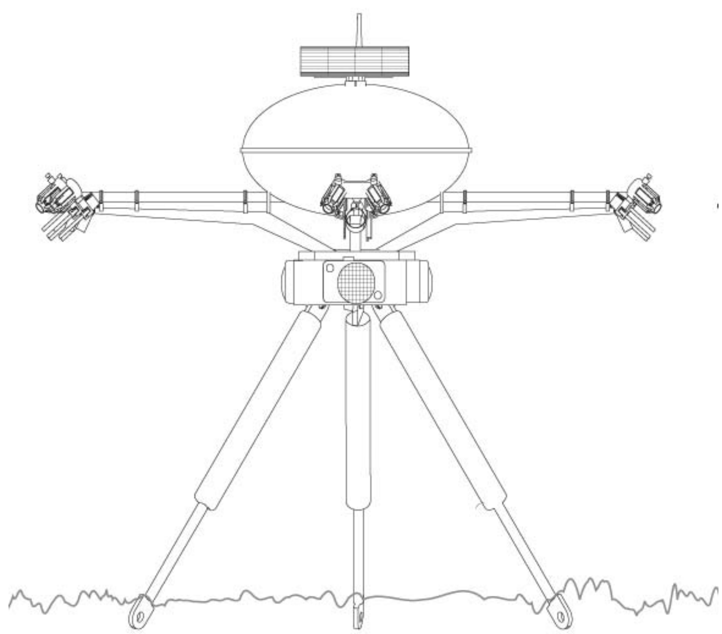
4.2 Biologic control

A biological control product has been available since the late nineties. It is based on a naturally occurring entomopathogenic (i.e. infecting insects) fungus, Metarhizium anisopliae var. acridum. The species M. anisopliae is widespread throughout the world infecting many groups of insects, but it is harmless to humans and other mammals and birds. The variety acridum has specialised on short-horned grasshoppers, to which group locusts belong, and has therefore been chosen as the active ingredient of the product. The product is available under different names in Africa and Australia. It is applied in the same way as chemical insecticides but does not kill as quickly. At recommended doses, the fungus typically takes two to three weeks to kill up to 90% of the locusts. For that reason, it is recommended for use mainly in the desert, far from cropping areas, where the delay in death does not result in damage. The advantage of the product is that it affects only grasshoppers, which makes it much safer than chemical insecticides. Specifically, it allows the natural enemies of locusts and grasshoppers to continue their beneficial work. It is crucial to be able to detect locust as early as possible in these remote areas. In this phase the Metharizium anisopliae bacteria is a very good substitute for the dangerous chemical insecticides necessary in later phases and closer to inhabited areas.

By equipping the LocuSent with a tank for the bacteria and a spraying system that is triggered by the sound of the locust, it would be possible, not only to monitor, but also to fight the locust in remote and hard accessed areas without going there. It is also possible to put up barriers of LocuSents in the expected route of existing swarms and creating "mine fields" that is completely harmless to everything except the desert locust.

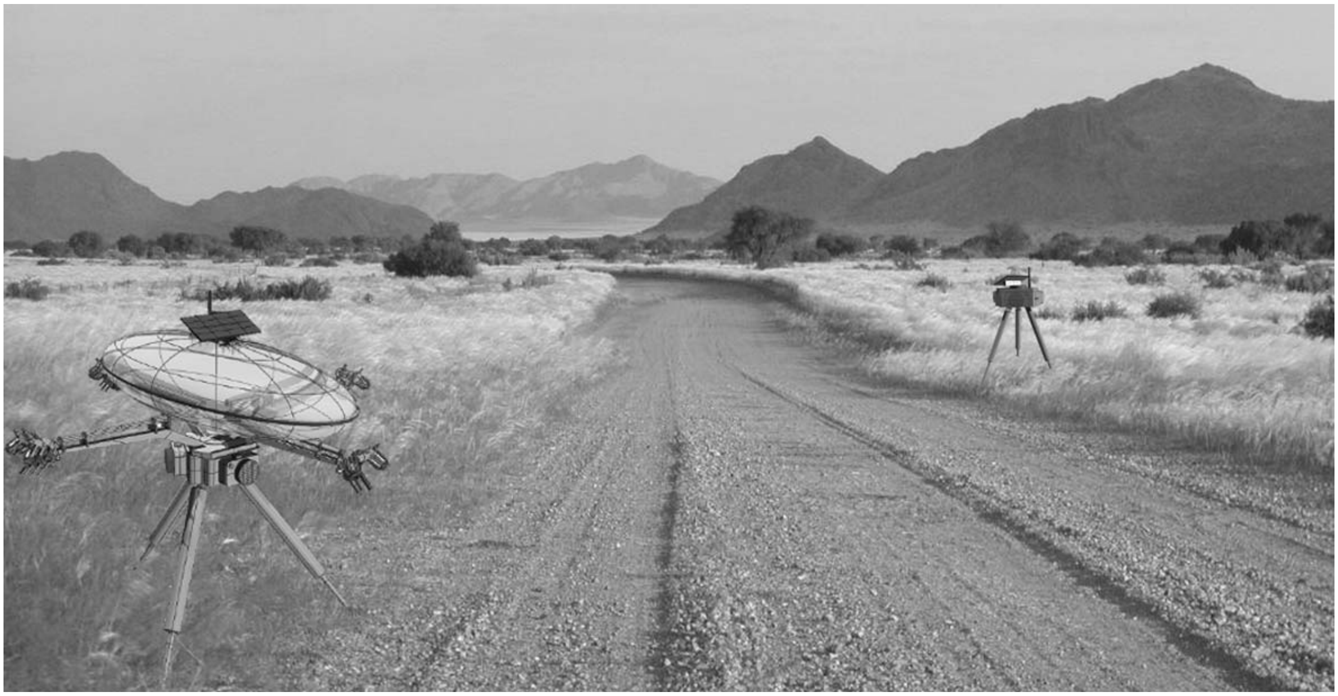


LocuSent control unit elevation a



LocuSent control unit elevation b

5. ILLUSTRATIONS



Sentient future competition
Vision for innovative applications

WISPHER: cooperating WIreless Sensors for the Preservation of artistic HERitage

(Case study: *Arena di Verona*)

Davide Del Curto
Department of Architettura e Pianificazione
Politecnico di Milano
Milan, Italy
Email: davide.delcurto@polimi.it

Franco Raimondi
Department of Computer Science
University College London
Gower Street, London WC1E 6BT
Email: f.raimondi@cs.ucl.ac.uk

Abstract

We propose a methodology based on cooperating wireless sensors to diagnose, control, and better preserve artistic heritage. Our aim is to provide a feasible framework to balance preservation issues with usability issues, both for open air buildings and for closed ones. The proposed methodology benefits from networks of cooperating sensors in two respects. Firstly, sensors are used to diagnose accurately the state of a building, to draw accurate thermo-hydrographic maps, and to understand the dynamics of exchange between the building and the environment (caused either by natural seasonal fluctuations, or by the use of the building). Secondly, sensors are used in the management of a building to react effectively to sudden changes of the environment, thereby enabling a better preservation strategy. We present an application of our methodology to a concrete example: *Arena di Verona* in Italy.

The rest of paper is organised as follows. The problem we want to study is defined in Section 1, while Section 2 presents the state of the art of currently employed diagnostic methodologies and preservation strategies. Section 3 introduces our framework, whose benefits are analysed in Section 4. Section 5 applies the methods to a concrete example: *Arena di Verona*.

1. Problem definition

Water (rain, moisture, environmental humidity), often combined with atmospheric pollutants, is the main cause of damage for ancient buildings. Indeed, ancient buildings are typically made of hygroscopic materials such as tile, stone, plaster, wood. Unfortunately, it is extremely difficult to diagnose and quantify the presence of water (in all its forms) and the way it damages buildings, museums, and the objects stored in these buildings. Such diagnostic exercise is even more complex in the case of open air (or partial open air buildings), for instance ancient amphitheatres.

To worsen the situation, the amount of artistic sites in Europe and the increasing number of tourists visiting them clashes with the need of preservation strategies. Indeed, it is not possible to close artistic sites to perform accurate analysis, which may require many seasonal cycles. Moreover, the presence of tourists may alter the values of temperature and humidity in a critical way, when compared with seasonal variations.

In parallel with these issues, some of the techniques available to measure critical parameters are too destructive to be performed on many buildings.

2. State of the art

There is no single strategy to diagnose, nor to maintain, artistic heritage, which may be explained partially by the fact that every site is different in nature. Currently, measures of rain, temperature, and humidity are typically carried out "punctually".

In closed environments, thermo-hygrometers exist to record series of data, and these instruments are actively used to monitor the state of the air in various settings. However, to the best of our knowledge, thermo-hygrometers *do not interact* with other kind of sensors, and they interact only in a limited way with air-conditioning devices.

In the case of "open" buildings, i.e., buildings without a roof, or with partial coverings, no instruments exist to monitor all the relevant dynamics of exchange between the building and the environment. Atmospheric pollutants can be measured with appropriate instruments, other devices can measure the amount of rain, the temperature distribution over a surface, and other parameters, but these devices have never been coupled in an automatic way with preservation strategies. Moreover, the possibility of remote control of these devices is very limited.

In essence, apart from few cases in closed environments, diagnostic campaigns and preservation strategies are implemented manually, *in situ*. These factors negatively affect the cost of evaluating the state of a building, thereby reducing the number of possible interventions. Even worse, the current preservation strategies may not be sufficient and/or they may be too slow to cope with sudden changes in the environment, both because of unexpected weather conditions, and because of the number of tourists visiting a particular site under particular circumstances.

3 Proposed solution

The aim of the proposed solution are:

1. To increase and improve the quality of the diagnostic procedure.
2. To plan and deploy low-impact protection strategies, which are easily reversible.

The outcome of the strategies devised in this way is a preservation procedure for artistic heritage, which allow people to access sites (both museums and open air buildings) without causing irreversible damages. A network of wireless cooperating objects may be implemented both for point 1 and 2 above, which correspond to two distinct phases in a project. For a generic building, the first phase of the methodology we propose will typically span over three years, and will includes the following items:

PHASE 1 - DIAGNOSIS

- Micro-climate analysis: a wireless network of sensors for temperature, relative humidity, wind speed of air; these sensors may be placed at different height levels, both indoor and outdoor, and communicate with an appropriate repository. Measures can be made to evaluate seasonal and short-term variations.
- Psycrometric analysis: sensors for the temperature, humidity, water content of the structures, connected with a central repository. These measures will be paired with the data from the previous point, to evaluate the reaction of the structure to micro-climate changes.
- Thermographic map: infra-red sensors will keep track of surface temperature variations with micro-climate changes. These measurements permit the evaluation of humidity spots caused directly by rain or by moisture.
- Rain analysis: apart from the absolute amount of water, radio emitters could be spread over a surface to trace the outgoing flow of water; measures of this parameters will be coupled with the remaining data to obtain the dynamics of water in a building (in our case study presented below, tracing the water flow with radio emitters could establish whether or not the ancient roman aqueduct is still in use).
- Pollutants analysis: sensors for pollutants (both in air and on the surface of structures) will return data to be coupled with the other parameters.
- Endoscopic, remotely controlled sensors may penetrate large sections of walls to investigate the composition of the structures. These would be occasional measures to characterise further the structures of a building.

All the measures presented above may be executed and checked remotely, thereby allowing a single research group to work at more sites in parallel, reducing the costs. Moreover, automatic and/or manual remote re-configuration of the devices will fine tune the results of this phase.

The expected outcomes of phase 1 are a detailed assessment of the possible causes of degradation of a building, a detailed map of the situation, e.g., the increase in humidity and temperature with tourists, the identification of weak sections of the structures after heavy rains, etc.

PHASE 2 - MONITORING AND CONTROL

The outcomes of phase 1 will be key to develop phase 2. In this phase, a cooperating network of sensors and actuators will be installed in the building / site to implement efficient preservation strategies. Typically, the following items will appear in the final strategy:

- Sensors for temperature and humidity (both for air and for surfaces). These sensors will detect sudden changes due, e.g., to the presence of tourists.
- Automatic gates: these gates will be controlled automatically by an appropriate device, communicating with the sensors for humidity and temperature. The idea is that sections of a building / site can be dynamically opened or closed, based on the number of tourists, on the humidity of air and of temperature, etc.
- Sensors detecting the amount of rain may open or close the appropriate drains, to divert the water tp the correct sinks.
- In a closed building, room-level air conditioning may be enabled automatically.

4 Benefits:

The benefits of the proposed methodology include:

- Accurate diagnosis of large buildings. This kind of analysis may be very expensive; the use of a network of semi-autonomous devices remotely controlled may reduce the costs of these operations.
- Possibility of monitoring large, open air buildings (such as amphiteatres). Similar controls exist in a small number of closed museums to control particularly sensitive rooms. However, to the best of our knowledge, no open-air or large building has been monitored yet. A network of wireless and cooperating devices is fundamental to this end.
- Rapid and effective response to sudden changes. This implies an increased safety for artistic heritage, and an increased availability to the public.

CASE STUDY: *Arena di Verona*
(and annex *Fondazione Arena per l'Opera Lirica*).

In this Section we present a scenario that may benefit from the proposed methodology: *Arena di Verona*.

<u>Historical overview:</u>
The amphitheatre was probably built during the Ist century B.C., during a peaceful period for the Roman Empire, and it was the place for public assemblies and fun events.
During the Middle Age, the *Arena* was abandoned and spoiled of its furniture, and it became an urban quarry for the stones used to build houses in the more recent centre of Verona.
The building started to be restored in 1480, according to a long public program that rebuilt the monument more or less as it appears today.

<u>Current problems:</u>
Surprisingly, there are no research reports, nor studies, concerning this important building. *Arena di Verona* is the most visited monument in the city of Verona, and one of the most popular in Italy.

Currently, the main problems are related with the presence of water. In particular, the following questions remain open:

1 The *Arena* has no roof nor coverings. Water falls in the *cavea* and dampens the whole structure. Some parts of the structure are permanently wet (see the figure in the next page). Where is the water flowing to? Are there any

preferential ways for the water flow, from the moment the water touches the *cavea* to the moment it reaches the ground? And where does the water flow to, after reaching the ground? Is the old roman aqueduct still working?

2 How does the water accumulation affect the inner microclimate and the thermo-hygrometric conditions of the structures? Is this sustainable in the future?

3 The popularity of the amphitheatre *Arena di Verona* is also due to the lyric season that crowds the amphitheatre from may to September. The *Fondazione Arena* that organises and produces the performances occupies nearly a third of a nearby building with warehouses, small rooms and spaces of service. Do the presence of tourists and the execution of performances cause problems to the structure for the sudden changes in microclimate? Is it possible to devise a relationship between the presence of people and the variations of the microclimatic conditions in order to plan solutions?

The following pages contain images recently taken from the *Arena*, showing damp surfaces in closed sections of the building. We argue that the methodology presented here may be extremely helpful in assessing the importance of such unexpected evidence.

PerSens: Personality Sensors

A Contribution to the Sentient Future Competition

Zinaida Benenson
Department of Information Technology
Uppsala University
Lägerhyddsvägen 2, 75237 Uppsala
zina@cs.rwth-aachen.de

Mesut Güneş
Department of Computer Science
Informatik 4
RWTH Aachen University
Ahornstraße 55, 52074 Aachen
guenes@cs.rwth-aachen.de

Martin Wenig
Department of Computer Science
Informatik 4
RWTH Aachen University
Ahornstraße 55, 52074 Aachen
wenig@cs.rwth-aachen.de

ABSTRACT

The deployment of sensor networks in the area of social relationships is very attractive, since by assisting people it may improve cooperation and prevent conflicts.

We propose the Personality Sensors system (PerSens), which consists of a sensor network embedded into the clothes and other accessories of the person. PerSens will determine the personality type of the owner. Besides, it will also notify the owner of his behaviour in the current context and how it may appear to his counterparts.

Keywords

Sensor networks, Social interaction, Personality type

1. INTRODUCTION

In all times, misunderstandings among social groups and individuals have led to conflicts. In a family, misinterpretation of the behaviour of the parents, children or partners may lead to loss of trust. In the worst case, this may lead to drifting apart of families and to divorces. The performance of working teams in companies depends heavily on the attitude of the individual members. This situation gets even more complicated in international working groups.

The improvement of social relationships will reduce potential conflicts and can help each and every person in their daily life. This can be achieved if the interacting parties are aware of their own characters and the characters of the counterparts. Of course, all people are different. However, some psychological theories classify people according to their personality types. One of these systems was invented in the beginning of the twentieth century by Myers and Briggs [1] and was successfully used by industry companies to form project teams which worked more efficiently. Their work was extended to relationship in the normal life by David Keirsey in his books [2]. Gunter Dueck applied this theory to the people working in the area of computer science and mathematics [3].

One of the challenges in applying psychological classifications is the development of tools for determining to which category a particular person belongs. The most frequently used tools are questionnaires. However, this method is unreliable. To name just a few problems, people usually cannot appraise themselves objectively, they may try to look "better" while answering the questions, or they may even misunderstand questions. Besides, the questionnaires are tiresome and boring. For example, there are five different questionnaires with up to 144 questions for the Myers-Briggs Type Indicator. These disadvantages may lead to incorrect classifications, and thus renders even the most promising theories useless in the practice.

The proposed system, Personality Sensors (PerSens), consists of a sensor network embedded into the clothes and other accessories of the person. PerSens will determine the personality type of the owner. Besides, it will also notify the owner of his behaviour in the current context and how it may appear to his counterparts.

The remainder of the paper is as follows. In Section 2, we give possible application scenarios for the use of PerSens. Subsequently in Section 3, we describe PerSens in detail.

2. SCENARIOS

We describe possible applications of PerSens on two selected examples from totally different domains. The first example discusses the deployment of PerSens in professional life, and the second example covers family relationships.

2.1 Project meeting

Consider a team in an important project meeting. As usually, some participants talk a lot, sometimes they even change their minds several times during the meeting. This is their method to find solutions. Other team members are very quiet. This can be misinterpreted as being uninterested. However, they may be listening carefully to the discussion and take time to consider the given arguments. In this situation, both personality types have a big problem. The "active" people would not listen to the "passive" colleagues. On the other hand, the "passive" people cannot make the others listen to them. As a consequence, suboptimal, or even wrong decisions might be made, and both personality types blame each other for the project failure.

The deployment of PerSens in the meeting informs each participant about the personality of the others. This enables the project leader and also the whole group to include every team member with regard to his personal strengths. PerSens determines the most efficient meeting schedule, such that "active" people have the opportunity to discuss things, and the "passive" people have the opportunity to observe the discussion.

Then PerSens notifies the participants about the most appropriate time to change the roles, such that "active" people have to listen, and the "passive" people have to talk. This way, all members are given the opportunity to learn new skills (listening vs. talking) and the project benefits from the diversity of ideas.

2.2 Family Quarrel

Misinterpretation of the behaviour of the family members often leads to serious conflicts starting from trivial causes. Partners may lose trust to each other, drift apart, divorce. Children and parents may part for years, or even for the whole life.

Alice and Bob, a married couple with different personality types, are going to have a quiet evening. Both of them already made concrete plans. Suddenly, their friends call and suggest to go out. According to her spontaneous personality type, Alice is willing to accept. In contrast, Bob prefers well planned activities and refuses to join. They spend the remainder of the evening in a blazing row, which will not be pictured here.

Now suppose that Alice and Bob got tired of their rows and go to the psychologist Charlie in order to improve their family life. Charlie installs PerSens for them, which eventually determines their personality types. PerSens helps them to understand each other better, and to find compromises. For example, they may agree to accept every other of unforeseen invitations.

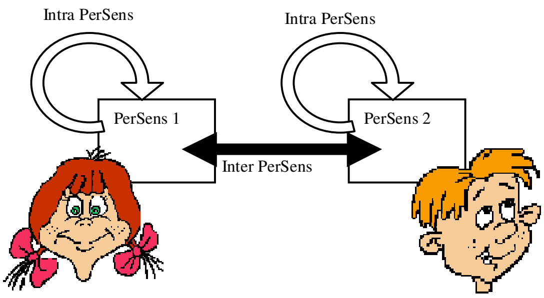
3. THE PerSens SYSTEM

First, we describe the requirements for intra PerSens which is responsible for determining the mood and condition of the owner and notifying him. Subsequently, the interaction of different PerSens' is described.

3.1 Intra PerSens: The Personality Type

The sensors are integrated into the clothes and accessories of persons. The sensors measure body temperature, heart rate, blood pressure, perspiration, and brain impulses. Furthermore, these data is connected to temporal and spatial contexts. This data will be transformed into information about the person's psychological condition. On top of the psychological condition, PerSens will generate advices and notify the owner.

PerSens has to be adapted to the owner in order to render useful



information. There will be a settling time during which the system determines an initial personality type of the owner. After this period, the system is ready to assist the owner. Nevertheless, there will be continuous observations of the owner to ensure the recency and validity of the assumed personality type.

As PerSens is integrated into clothes, it needs a mechanism to identify the current carrier. This can be done by measuring some characteristics like walking type, typical heart rates, and other unique properties of the person.

3.2 Inter PerSens: Interaction

When persons' PerSens meet other persons' PerSens, they interact by sharing personal data. Of course, this implies the agreement of the respective partners to share information about their personality type and current mood. Given this agreement, PerSens may exchange information with respect to the current context and suggest appropriate behaviours to the respective owners. The context determines the amount and the quality of the exchanged data. In the following, we give two illustrating examples.

- The-Mother-Child-Dog-Story: Consider a mother together with her child meeting a loose dog. In this situation, the nervousness of the mother should not be evident to the child.
- The-Business-Negotiation-Bluff-Story: When business partners negotiate contracts, they have to conceal their emotions such as pleasure, anger, or uncertainty. Nevertheless, PerSens can help to find a compromise faster, and to improve business relationship.

4. ACKNOWLEDGEMENTS

We are grateful to Anna Chudnovsky [4] for the fruitful discussions about the application of the Myers-Briggs theory to real life.

5. REFERENCES

[1] The Myers and Briggs Foundation, http://myersbriggs.org/

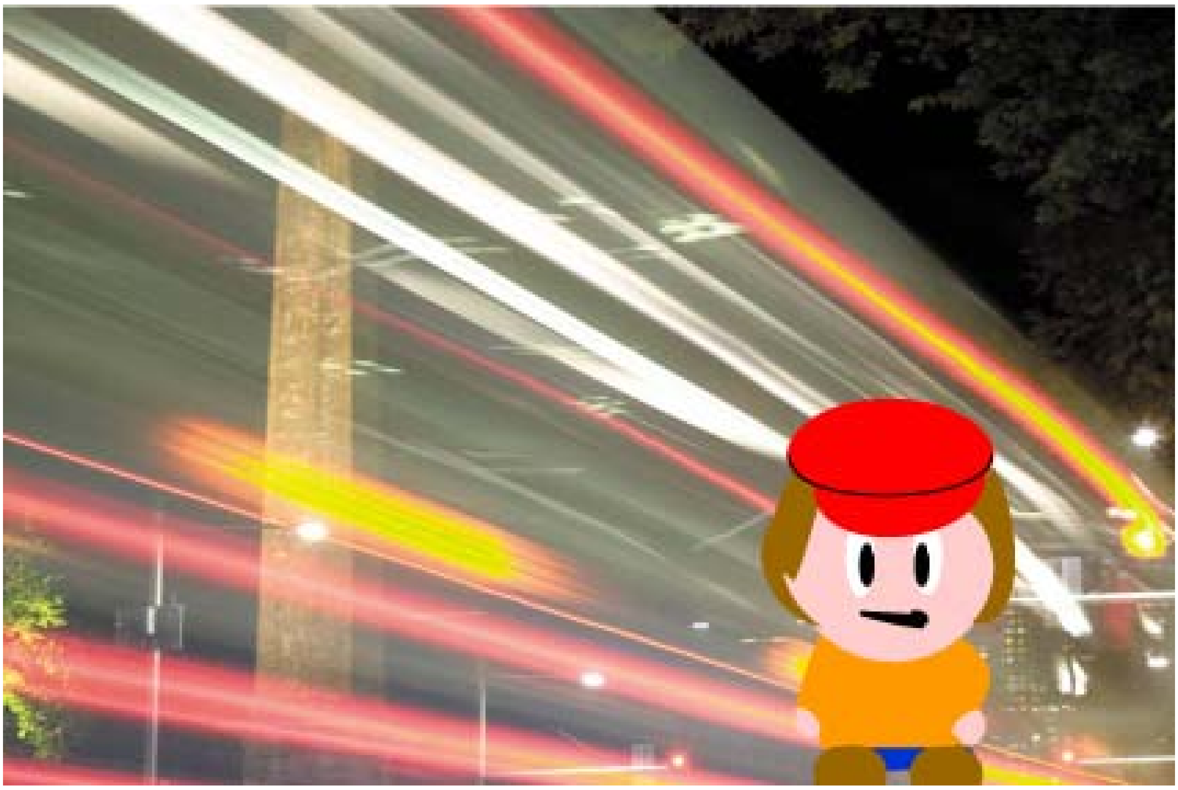
[2] Keirsey, David, Please understand me I&II, http://keirsey.com

[3] Homepage of Gunter Dueck, http://www.omnisophie.com

[4] Chudnovsky, Anna, Читать человека как книгу (Reading people like a book, in Russian), http://2a.ru/

Sentient Guardian Angel

Contribution to Sentient Future Competition – Vision 2015



Authors:

Marcus Christ, Gerald Eichler, Klaus Miethe, Stefanie Richter, Jens Schmidt, Jens Wukasch

Private federation of people interested in research and development of new ideas.

Contact Person:	Stefanie Richter
Address:	Dieburger Str. 32, 64287 Darmstadt, Germany
E-Mail:	mail@stefanie-richter-online.de
Phone:	+49 177 6947732

Darmstadt, November 30, 2005

1 Sentient Guardian Angel

1.1 Motivation

This proposal emphasizes the use of wireless sensor networks to omit dangerous traffic situations for elderly pedestrians, children as well as for disabled persons and pets. Communication between the networks of the participants is used to detect the threat at an early stage giving adequate warnings, alerts recommendations and instructions to all participants involved.

1.2 State of the Art

The statistics for traffic accidents show increasing rates for accidents with children or seniors involved [1]. Noise reduction of motorized vehicles is estimated to contribute to this tendency as well as increasing mobility as well as people getting generally older.

Despite the fact of an increasing number of sensors, making life for drivers and passengers of cars easier and safer there are no systems assisting pedestrians or cyclists. Examples for driver assistance systems are e.g. Daimler Chrysler's Distronic, a radar based distance control [2] and Daimler Chrysler´s Dedicated Short Range Communication (DSRC) system under development [3].

Clothes attached with different kinds of sensors and actors (I-wear [4]) can be used as appropriate equipment for pedestrians and cyclist to enable “Sentient Guardian Angel” functions.

1.3 Vision

The sensor system is supposed to prevent dangerous traffic situations in everyday life. Imagine a handicapped person intending to cross a street. The pedestrian's perception and attention is limited.

The following pictures illustrate such a situation as well as the point of view of the pedestrian and the vehicles driver.

A handicapped pedestrian (e.g. deafness) intents to cross the street. As a car is approaching he does not recognize the vehicle because of his handicap.

However, the Sentient Guardian Angel builds an ad-hoc network exchanging information. The system evaluates the information and recognizes the approaching car.

The driver of the car might not realize the pedestrian as well, e.g. due to bad weather conditions. The Sentient Guardian Angel recognizes the pedestrian and sends warnings to the driver. This enables the driver to react on the "abruptly" emerging person.

The system guards in several cases:

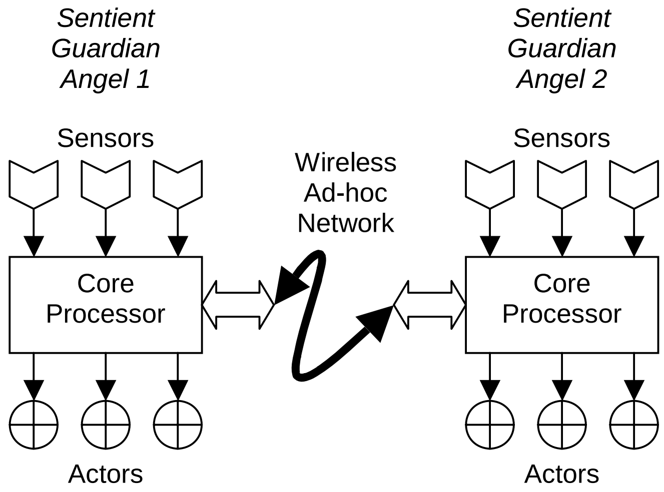
- The pedestrian is warned by the system, e.g.,
  - Causing vibration on the concerned side of the persons body
  - Causing noise or other warnings
- The pedestrian draws attention due to actors
  - The person is illuminated or the clothes are separating coloured light
- The vehicle driver is warned by the system.
  - A sign flashes next to the car's dashboard
  - Causing noise or other warnings
- The vehicle warns the pedestrian
  - The headlights of the car flash up
  - The car alerts a horn

1.4 Technical Architecture

The basic equipment of the Sentient Guardian Angel is a system consisting of the following components:

- Sensors (to detect and quantify environmental factors)
- Actors (to indicate dangerous situations and give appropriate advice)

- Wireless communication components (to build ad-hoc networks between involved parties)
- Core processor (to control components and predict critical situations)



Such a system will be designed for each traffic participant following its special needs regarding its role (pedestrian, cyclist, motorist) and its characteristics (child, elderly person, disabled persons). Therefore different sensors and actors are needed.

Different research activities exists to realize highly miniaturized and autarkic acting systems (hardware, platforms) using wireless communication. Examples for these research activities are µ-OS such as TinyOS or ContikiOS [5] and e-Grain [6]. Therefore the dimensions of the necessary components for the Sentient Guardian Angel are expected to be very small-sized.

1.4.1 Components of the System

1.4.1.1 Sensors

Sensors are needed for two main reasons. Firstly, to detect the personal behaviour in a certain traffic situation, which is characterized by a “motion vector”. Therefore

- Location (position) and orientation (compass)
- Velocity and acceleration sensors

are needed. Alternatively precise location sensors could be of interest.

Secondly, sensors which detect the presence of other traffic components are required. This could be statical things like traffic signs or traffic control equipment e.g., traffic lights or dynamical things like other traffic participants. There are two ways of detection. The local detection by

- Noise pattern sensors
- Video pattern sensors
- Ultrasonic sensors

and the intercommunication sensors by active near and medium field communication using active wireless technologies like

- RFID tagging
- IrDA and Bluetooth communication
- Classical RF transmission on an ISM band

1.4.1.2 Actors

Actors are specific to the role and the characteristic of a traffic participant. While motorists will have a specific unit integrated in the car control system with audio and video output the actors of pedestrians should be smoothly integrated in functional clothing. The so called “Active Jacket” could have all components at a sufficient place. Examples are:

- A speaker in the neck for noise alarm and speech output
- Vibration or thermo actors in the sleeves
- Flash lights to warm other traffic participants

One can see that there are two ways of indication, firstly to warn the person itself and secondly to warn others.

In addition, augmented reality technologies can be used for visualisation of alerts or critical situations. Visualization can be done on the windscreen in cars/tram/buses, on visors of helmets and on augmented reality enabled eyeglasses.

1.4.1.3 Wireless communication / Ad-hoc networks

While sensors and actors mainly interact with the local core processor, the wireless communication components are responsible for interaction between traffic participants. “Ad-hoc networks” are build as soon as at minimum two potential entities come into a certain distance. Multiple such threads have to be handled in parallel. Each node in an ad-hoc network is able to act as a router to relay connections or data packets to their destinations. This is necessary if more than two objects are part of the ad-hoc network. Ad-hoc routing protocols are under standardisation.

1.4.1.4 Core processor

While the initial approach relies on a core processor to coordinate sensors, actors and wireless communication components in a second step the local equipment of a traffic participant could be build of a modular sensor network itself. Active jackets could be designed quite easier.

1.4.2 System Operation

As soon as an ad-hoc network connection is established, there will be an exchange of two information:

- The “motion vector”, which allows a prediction of further movements and a calculation of potential crash situations
- The “characteristic set”, which informs about the role and characteristic of the traffic participant

The correlation of two motion vectors allows a prediction of potential crash situations. Therefore any change of one vector has to be reported to the other party. As long as there is no crash course identified, no reaction is required.

The characteristic set has to be exchanged only once between involved parties. It is quite important as children, elderly people and disabled people show quite a specific behaviour within traffic situations. This influences the selection of actors and looks for specific information for the opponent party e.g. a driver could be informed about a deaf person with the intension to cross the road. The local decision finding, implying several steps like “indication”, “warning” and “advise” will be supported adequately.

The power supply of the active jacket will be supported by distributed generators using:

- Temperature differences
- Movements by pressure generation
- Movement by acceleration generations

1.5 Approach

The first step to enable the Sentient Guardian Angel is the development of sensor systems for pedestrians, cyclists and for motorists, respectively the cars. These sensors are able to build ad-hoc networks and exchange information. According to the part of the system (pedestrian or vehicle) the information is evaluated and the sensor system provides the car driver or the pedestrian with warnings of an approaching dangerous situation.

After the establishment of such a sensor system road infrastructure e.g., traffic signs can be integrated by tagging mechanisms. This will help the sentient system to evaluate information regarding the environment of the situation.

As first step it is proposed to start with the requirements of pedestrians having handicaps like deafness. In further steps one might consider other handicaps, elderly persons, children and pets.

The Sentient Guardian Angel is supposed to guard pedestrians. It sends warnings and advices to either the vehicle driver or the pedestrian. Later it could be an assistant e.g., to help a vehicle driver to automatically react in dangerous situations. Additionally, it can become a topic for telematic and navigation aspects regarding vehicle systems.

2 Addition Information

2.1 References

[1] URL: http://www.im.nrw.de/sch/736.htm

[2] URL: http://www.daimlerchrysler.com/dccom/0,,0-5-7165-1-464031-1-0-0-0-0-0-243-7165-0-0-0-0-0-0-0,00.html

[3] URL: http://www.daimlerchrysler.com/dccom/0,,0-5-7182-1-465281-1-0-0-0-0-0-243-7165-0-0-0-0-0-0-0,00.html

[4] URL: http://www.i-wear.com/

[5] URL: http://www.sics.se/

[6] URL : http://www.egrain.org/

2.2 Accompanying Documents

- Flash Demonstration

Please start the flash by double-click.

You can act as an attentive driver by moving the car with the mouse to the left (sorry, continental way of driving ;-))

For the next scene please click on “Next step”.

Sentient Future Competition: SmartSoot

Patrick Andrews
Break-step Productions Ltd, UK

Smartsoot

I tapped twice on my forearm and the control patch appeared. Once I selected 'mymood' the soot took on a sombre dark blue shade with scrolling pinstripes. I'd started the day feeling buoyant but now my heart was literally on my sleeve.

My flesh-and-blood attorney and I had only ever F2F'd once before, so something serious was about to happen to me (something lucrative for him). Most likely, one of my portfolio of employment contracts had sensed it was being infringed -probably based on eavesdropping by some rumour sniffer. My legal guy was really just a disillusioned former plumber with a degree from Senegal and a second-hand expert system -he was still using email for Christ's sake…

…but he had helped after the attack. Some bloke had gone for me with a knife last year. He'd probably been disconnected for e-con or spamania…or maybe just attempted irony. Outnets are usually forced to wear those stick-on neurode caps -just so they can't sneak up on anyone, without their intention map lighting up red.

(The same thing had once been marketed to couples: women could monitor their husbands' requirements for sport, beer and other men's wives. Men, however, found the transient patterns which appeared on females' caps, way too complex).

Normally, my soot would have sensed the air pressure changes and the shadow of the deranged guy's hand; but it seems it was distracted by some interference from a pedestrian meter and was slow to stiffen the impact region. I got minor neural damage in my right arm, which for a part-time Road Traffic Controller, was kind of problematic. A patch of nerve substrate had to be sprayed on the wound. Still feels like I'm wearing an extra gesture glove, but better numb than phantom limb.

(All that automated traffic management we'd installed had taken just two weeks to generate global gridlock. I'd spent the last 18 months untangling a 300 sq km jam, caused by a flaky subroutine and some 1derkind on a Sinclair C9 who couldn't tell left from right).

Way back in the days of the late 1nternet, The Ministry had gone crazy when the first neurode machines became available. They came as a kind of paste: laughable really, compared to the spray-on we use today. Soon they decreed that every roof had to carry 1 sqm of black paste in order to gather met data (for unstated reasons to do with "National Security"). This was all funnelled back to a googleputer somewhere which could predict rain on any given patch a week in advance. It's actually become valuable though, since my soot, for all its cleverness, would be vulnerable to a good soaking with the dirty rain that's the only kind we get now. I had, like everyone I met over the last decade, become my own personal n-ternetwork. Personal, we soon discovered, wasn't the same as private.

I stopped to get some buttered toast or some psychoc from a Provender in the street. Of course, it had a terse conversation with my gutbot and then my insurance policy must have cut in with the usual warning of:

> “WARRANTY INVALIDATION (LIFESPAN DECREMENT 2.5 HOURS, APPROX).”

I was so mad, I had a flash of redcap and punched the Provender -hard enough to wake up some of those synthetic circuits of mine). Its self defence routine caused it to scream like a frightened child. There was no choice but to hug it better (the damn thing wouldn’t stop until it could “*feel I meant it*“). I made a mental note to unsubscribe from the healthcare channel but of course I was overruled by an actuary agent I didn’t even know was on my staff.

A part of me had started yearning for the old days when grass only came in green and it was possible to lose things…when there was quiet, with no threat of disembodied updates or warnings: no backchat from faceless smartifacts. Was it really too late to become a neoluddite monk?

Then, unexpectedly, it began to rain.

D. Appendix D: Workshop on Social Aspects

Social Aspects of Cooperating Objects Technologies

International Workshop
of the Coordination Action Embedded WiSeNts (IST-004400)

November 1-2, 2006, Technical University Berlin

Workshop Report

December 14, 2006

Eric Töpfer

Center for Technology and Society
Technical University Berlin
www.ztg.tu-berlin.de

Table of Contents

Introduction

In the early 1990s Mark Weiser outlined his vision of the computer for the 21st century at Xerox Palo Alto Research Center as ubiquitous "calm technology" which weaves itselves into the fabric of everyday life until becoming indistinguishable from it (Weiser 1991; Weiser & Brown 1995). Since then progress made in the domains of processing power, data storage capacities, wireless networks technologies, human-machine interfaces, miniaturization and convergence of devices is impressive.

As Greenfield (2006) notes there are many ubiquitous computings, which (or at least aspects of have it) are also called pervasive computing, physical computing, tangible media, ambient intelligence, Internet of Things, or – to use his term – "everyware". The assembly of this puzzle, Greenfield argues, has "reached something like a critical mass of thought and innovation by 2005". Thus, he concludes, information technology is prepared to colonize everyday life "to remake the very relations that define our lives".

The dramatic social implications that might arise from this emerging field of technology have also caught the attention of the Embedded WiSeNts consortium, a network of leading European academic research labs and institutes in the areas of embedded systems, ubiquitous computing and wireless sensor networks. The Embedded WiSeNts consortium aims to push the vision of so-called cooperating objects by supporting the integration of existing research, developing a roadmap for technology adoption and promoting excellence in teaching and training.

Given both their fascination and concerns the lead researchers of Embedded WiSeNts commissioned the Center for Technology and Society (CTS) of the Technical University Berlin (TUB) to organize a workshop on the social aspects of cooperating object technologies and ubiquitous computing. Therefore the CTS invited 15 experts in technology assessment, sociology of technology, participatory design, system analysis, communication science, privacy protection, psychology, micro economics and the philosophy of law from across Europe to provide an opportunity for both an interdisciplinary exchange and a discussion of the issues at stake with computer scientists and engineers from the Embedded WiSeNts network.[1]

This expert workshop was held at November 1-2, 2006 at the TUB. In total 37 persons registered for participation and 35 were eventually present. The central objective of the workshop was to present state-of-the-art research from different disciplines, and to identify the key challenges arising from the current technological developments across these different strands of research. Moreover, it aimed to discuss approaches of socio-technical design that integrate engineering and social research at the meta-level of devising

[1] *Social Aspects of Cooperating Objects Technologies*, International Expert Workshop, Website: http://www.embedded-wisents.org/workshop/.

regulation and at the micro-level of shaping applications and devices. Last but not least the findings of the workshop were meant to inform and support the efforts of the Embedded WiSeNts consortium to map the future of cooperating objects technologies.

This report summarizes the presentations given at the workshop and the discussions they provoked. It is organized according to the five panel sessions of the workshop and finally outlines key challenges for future research and policy making.

Summary of Panel Sessions

Following the welcome notes by Adam Wolisz, director of the Telecommunication Networks Group at TUB and coordinator of Embedded WiSeNts, and Werner Rammert, Professor for technology studies at TUB and speaker of the CTS, Marcelo Pias from the Computer Lab of the Digital Technology Group at the University of Cambridge gave an introduction into the technological state of the art. He presented selected visions for application and a framework for discussion. The central question that Pias raised was whether the presented visions are sufficiently useful to justify their impacts. The key issues he proposed for discussion in the following panel sessions were:

- privacy,
- digital divide,
- usability,
- role of governments and the private sector,
- ethics,
- sustainability.

The following five panel sessions were organized around five topics:

1) Grand challenges as identified by recent surveys on ubiquitous computing and ambient intelligence,
2) the governance of risk, privacy and trust in cooperating objects environments,
3) the assessment of user expectations and the anticipation of practices of use,
4) the calibration of distributed agency in human-machine interaction,
5) the management of complexity in socio-technical networks of cooperating objects and humans.

Panel Session 1: Grand Challenges: Lessons Learned from Recent Surveys

Albert Kündig, retired Professor from the Swiss Federal Institute of Technology (ETH) Zurich and member of the steering committee of Technology Assessment (TA) Swiss, began his talk with the statement that computing – understood as a metaphor for the totality of ICT and their applications – does not introduce a fundamental new aspect into human life and the social fabric as information handling is a key characteristic of human existence at least since the invention of script. ICT, he continued, only changes the performance of our information handling tools but this, however, dramatically as these tools have become globally available. What is new about ICT in general and about cooperating objects in particular is that in contrast to mechanic systems like the early locomotive the rules for the cooperation of the components of these information systems are increasingly dissociated from the physical objects while at the same time embedded into virtual bonds that are defined by logic rather than physics. Given the increasing complexity of ever wider networks of cooperating objects Kündig predicted that life might become more comfortable on the one hand while becoming more adventurous on the other hand. Having said this, he raised the questions, how adventurous life shall and will become with computing heading towards ubiquity, and how we can prevent people from becoming incapacitated cyborgs. To approach these questions and reach fair and differentiated answers, Kündig argued, clear definitions and a valid and differentiated taxonomy are required as technology assessment based on catch-all definitions usually faces the problem only being able to conclude that "technology is ambivalent". He stressed that technology assessment must look at technologies at the application level and proposed a set of descriptors for the development of taxonomies: 1) *scope* of the new systems in space, time, scale and functionality, 2) the *degree of coupling* of components, 3) their *autonomy* and *capabilities*. According to Kündig most of the published studies have not been made with such a proposed differentiated view. Given the manifold problems that are likely to be posed by the new applications, he notes, that still a lot of research has to be done. Finally, Kündig suggested to study socio-technical constellations rather than to follow traditional approaches of focusing either on the genesis or the impacts of technology. Thus, he concluded with an appeal for multidisciplinary, comparative and historic research as implied by the analysis of socio-technical constellations.

A recent study [2] commissioned by TA Swiss was presented by **Lorenz Hilty**, from the Department for Technology and Society at the EMPA Sankt Gallen. Though the main topic of this study was electronic waste and the challenges that pervasive computing poses for sustainable development it also addressed other issues and risks. What Hilty described as the main problem of the study was the fact that is aimed to assess a technological vision before it materializes. Thus, the team eventually chose a qualitative approach and developed a "filter" to rank those risks that are already discussed by the relevant literature. The following key issues were identified as most relevant from the perspective of the precautionary principle: 1) *Stress imposed on the user* by, for instance, poor usability, disturbance and distraction, concerns because of potential surveillance or possible misuse, and increased demands on individuals' productivity and other rebound effects. 2) *Restriction of freedom of choice* as pervasive computing may drive certain groups of the population into a situation in which they are compelled to use such technology or to co-finance it against their will. 3) *Setbacks for ecological sustainability* in face of the likely increase in consumption of scarce raw materials for the production of electronics and the energy consumption of stationary ICT infrastructure. Furthermore, the electronic waste generated by millions of very small components might result in an irreversible loss of resources and serious environmental pollution. 4) *Dissipation of responsibility in computer-controlled environments* is very likely to result in situations where it is not possible to

[2] *The Principle of Precaution in an Information Society: Pervasive Computing and its Effects on Health and on the Environment*, http://www.ta-swiss.ch/e/arch_info_perv.html.

isolate the cause of damages due to the combined effects of several components from computer hardware, programs, and data in networks, and thus to assign liability. In more detail Hilty elaborated the implications of pervasive computing for ecological sustainability and for responsibility and liability.

Another recent study [3] which was commissioned by the German Federal Office of Information Security (BSI) was presented by **Ernst Andreas Hartmann**, Acting Professor for ergonomics at the University of Magdeburg. The aim of the PerCEntA study was to deliver a prospective analysis of the technology impacts of pervasive computing. In detail, it should develop application scenarios, describe development paths and identify critical applications with respect to privacy and IT security. A multi-method approach was chosen combining desktop research, in-depth interviews with five experts using a modified conceptual structuring technique derived from psychological studies, and an online questionnaire sent to 300 experts in the field of pervasive computing. Hartmann reported that 83 experts eventually answered the questionnaire in summer 2005 with a bias of the sample towards scientists and Germans. The findings suggest that the experts believe that most application areas develop within the next ten years – with mobile communication and logistics in less than five years. Among the features of pervasive computing the experts believe mobility and ad-hoc networking to be fully realized within less than five years while energy autarky and autonomy is only believed to be realized within the next decade. The experts identified energy supply, the development of adequate human-machine-interfaces and technical safeguards as most crucial technological challenges for the further evolution of pervasive computing. Most experts agreed that "design for privacy" methods should be implemented right from the beginning as otherwise privacy issues are very likely to emerge with the diffusion of pervasive computing applications. In addition, most experts agreed that the recycling of electronic components will become a serious challenge and need to be addressed as soon as possible. But most experts were convinced that the overall benefits of pervasive computing outweigh its drawbacks. Only a minority thought that it might entail dramatic changes in social behavior. On the basis of the survey, Hartmann concluded with the forecast, that stand-alone devices will dominate the field of pervasive computing for the next five years while full networking will be realized with increasing capabilities in 2015.

Panel Session 2: Governing Risk, Privacy and Trust in Cooperating Objects Environments

Martin Meints from the Independent Center for Privacy Protection Schleswig-Holstein presented the findings of two recently published studies: 1) the project *Technology*

[3] *Pervasive Computing: Entwicklungen und Auswirkungen* (PerCEntA), http://www.bsi.bund.de/literat/studien/percenta/index.htm. The English version of the study is published by SecuMedia Verlag, Ingelheim (ISBN 3-922746-76-4).

Assessment of Ubiquitous Computing and Informational Self-Determination (TAUCIS) [4] which was funded by the German Federal Ministry for Education and Research, and 2) the study "Radio Frequency Identification (RFID), Profiling, and Ambient Intelligence (AmI)" [5] edited by the European Network of Excellence *Future of Identity in the Information Society* (FIDIS). Though both studies address issues of data protection, liability, criminal law and the social and socio-economic aspects of ubiquitous computing and AmI Meints focused in his presentation on privacy and data protection in relation to both the right to informational self-determination as declared by the German Federal Constitutional Court in its Census Verdict in 1983 and the German Federal Data Protection Act (addressed by TAUCIS) on the one hand and the European Data Protection Directive 95/46/EC (addressed by the FIDIS) on the other hand. As a key feature of current visions of ubiquitous computing and AmI is the candid collection of large amounts of (personal) data both studies conclude that these technical visions run against fundamental data protection principles as data minimization and informed consent by the data subjects to the collection of their data. Moreover, it is very likely that decentralized and multilateral service models and the different functions and roles of service providers increase the complexity and opaqueness of data processing in the context of ubiquitous computing and AmI, and therefore challenge traditional notions of liability, trust and risk management. Therefore Meints raised the questions how traditional data protection solutions such as informed consent and opt-in by the data subjects could be realized in AmI environments and which legislation could apply to a globally dispersed processing of personal information extracted from data subject. Meints reported that both studies conclude that no pure legal solutions can be found to these challenges but that they instead propose a combination of law and law enforcement, technical solutions and business models. Regarding the legal domain the following measures were discussed among others by the TAUCIS study: (1) strengthening the liability of operators of ubiquitous computing systems and domestic authorities and include also immaterial damages, (2) strengthening the possibility of users to enforce their data protection rights and (3) application of the strongest data protection standards in systems that are run by service providers at an international scale. In the FIDIS study concepts for (1) transparency enhancement and corresponding technical implementations and (2) "ambient law", i.e. the inscription of legal principles into technology, are discussed.

Safeguards in a World of Ambient Intelligence (SWAMI),[6] another project addressing issues such as privacy, risk and trust, was presented by **Ralf Lindner** from the Fraunhofer Institute for Systems and Innovation Research. The objective of SWAMI was to identify social, legal, organizational and ethical implications and risks of AmI in relation to privacy, identity, security, trust and digital divide, and to identify research and policy options on

[4] TAUCIS, http://www.taucis.hu-berlin.de/content/de/ueberblick/english.php.
[5] Hildebrandt, Mireille and Martin Meints (ed.): RFID, Profiling and AmI, FIDIS Deliverable 7.7., http://www.fidis.net/fileadmin/fidis/deliverables/fidis-wp7-del7.7.RFID_Profiling_AMI.pdf.
[6] SWAMI, http://swami.jrc.es/pages/index.htm.

how to design and implement appropriate safeguards in AmI systems in order to ensure user control and acceptance. To meet this aim SWAMI developed four “dark scenarios”, i.e. undesirable scenarios of a possible and realistic AmI environment for the year 2020, in order to highlight potential threats and vulnerabilities. (Dis)trust turned out to be a key issue for AmI applications due to their potential abuse, inadequate profiling, loss of control and discrimination. The problem of dealing with trust in AmI and its translation into “computational trust”, Lindner argued, is that trust is a social phenomenon which is still far from being fully understood – trust is mutable, highly context dependent and largely determined by individual characteristics. Given the unclear and fluid nature of trust, Lindner concluded that the incorporation of human trust mechanisms into AmI systems is extremely challenging as even a comprehensive collection of user’s data pose the challenge of adequate interpretation. Thus, Lindner raised the question whether the nature of human trust is compatible with “computational trust” which aims to imitate the former. As possible approaches to counter these problems it was recommended 1) to limit computational trust solutions to specific and clearly defined situations, 2) to confine AmI applications to the assistance of users’ decisions rather than allowing technical systems to make decisions on their behalf, and 3) to develop non-technical solutions such as independent trust audits and seals, credibility-rating systems, ISO guidelines etc.

Panel Session 3: Assessing User Expectations and Anticipating Practices of Use

This panel session was opened by **Somaya Ben Allouch**, PhD candidate at the Department for Communication Science of the University of Twente. In her talk she presented the findings of two studies on the representation and design of AmI applications for private homes: The guiding question of both studies was how users of AmI are conceptualized by marketing experts and designers. To study the visions and portrayals of users brought by companies and their marketing branches to the public Ben Allouch analyzed the textual and visual content of public relation material promoted by eight companies. To study the assumptions of designers with both a technical and a non-technical background she carried out expert interviews with 27 persons. The study of the textual promotion material showed that slogans of correctedness, easiness, control and personal dominate the representation of AmI while, for instance, privacy and security are not mentioned. Users portrayed in the visual advertisements are mostly represented as male young adults situated in their living room or in front of neutral backgrounds. The interviews with designers revealed that the easy-to-use vision as well as the low interest in privacy issues is shared by them. As target groups the designers approach “people who are highly interested in technology with a lot of affinity in that area and with a bit of money” as Ben Allouch quoted one interviewee. Interestingly the design experts pursue a push strategy and hope that people will get attached to their new AmI environments and therefore complement the ease-of-use vision with usefulness as a crucial characteristic.

Finally, Ben Allouch pointed to her ongoing but not yet finished research which, in a last step of the overall study, examines how users respond to the promises of marketing people and the visions of designers.

A microeconomic perspective on experimental testing of people's responses to the negotiation of privacy in exchange for rebate incentives was presented by **Dorothea Kübler** from the Faculty of Economics and Management at the Technical University Berlin. A first approach proposed by Kübler examines the emergence of mutual expectations concerning the use of technical artifacts in relation to the users´ privacy concerns. This is done by an experimental setup where test persons negotiate privacy contracts. In this approach expectations mediate between user strategies and technology (human-machine-interaction). The second approach draws on economic models of users and investigates by formal modeling the following puzzle: Why do people often share data though they claim to be concerned about their privacy? Finding reference points for collective expectations through formal modeling can contribute to the forecast of consumption patterns.

Matt Jones from the Future Interaction Technology Lab, Department of Computer Science, Swansea University in Wales challenged in his talk some of the key visions of ubiquitous computing and illustrated his arguments by drawing on his recent work in the area of mobile interaction design. Under the slogan "Not making things but making sense of things!" he showed how approaches to enroll people as "cooperating objects" of technically mediated interaction often fail as they do wrongly anticipate a certain style of user behavior as a precondition to make the applications work. Jones used the iPod as an example that innovative technology must not necessarily be hidden because people often like to embrace and display technology. Moreover, he pointed out that users are not technological but ecological people and, thus, do of course use all senses and available resources rather than only the digital. He reported that he and his team do experimentally test new applications that they have developed in order to study user expectations and experiences. As an example for this approach Jones concluded with a hint to an ongoing project, Story Bank,[7] a "sandpit" for participatory planning of human-centered computer technology to enhance life in an Indian village.

A related approach of participatory design was presented by **Dan Shapiro**, Professor of sociology at the Lancaster University, with the EU-funded international project *Palpable Computing: A New Perspective on Ambient Computing* (PalCom).[8] Shapiro explained that palpable computing shall complement the vision of ubiquitous computing: paradigms of invisibility, automation, or heterogeneity shall be complemented – or even replaced for selected applications – by visibility, user control and coherence. To address real needs when developing ICT applications the PalCom-project employs an interdisciplinary design

[7] Story Bank, http://cs.swan.ac.uk/storybank/index.php.
[8] Palpable Computing. A New Perspective on Ambient Computing. PalCom, http://www.ist-palcom.org/.

approach which integrates computer scientists, engineers, product designers and sociologists. As a test case PalCom studied work practices and the use of pilot devices and applications in a training situation for disaster management and victims treatment at the Major Incidents Future Lab in Aarhus (Denmark) in September 2005. In this test case several typical situations and settings such as the on-site use of biomonitors for victims, a medical coordination center or a surprise emergency drill were simulated. The (inter)actions of personnel and technology were studied by different methods of social research. To examine what needs to be done, for instance, to make biomonitors or visualization technologies useful the involved medical and emergency staff were asked what they need and how they assess the technology. Thus, Shapiro and his colleagues, found that their test persons demand solutions to confirm the correct association of biomonitors (solved by blinking in a synchronized pattern), on-site staff claiming that they need to control cameras for supervision by themselves, or command-and-control personnel in need to validate incoming information. What was more, to go beyond this interview-based approach of participatory design the team of sociologists studied situations by video-supported ethnographic observation to unveil more or less subconscious individual behavior and collective interaction that is also crucial for dealing with emergencies. To demonstrate the importance of such (inter)actions and the ethnographic method as a tool of its analysis Shapiro showed the “dance” of a firemen and an emergency doctor: With subtle gestures (“embodied conduct”) both display their “overview” and understanding to each other and the other people on the scene. Drawing on this example of involved human behavior and coordination in (extra)ordinary situations Shapiro concluded that it is always more complicated than it seems at a glance. Therefore he recommended that developers and designers should keep their applications specific and simple in order to avoid problems by unsuccessfully simulating and substituting complex social interaction. Moreover, Shapiro concluded, they should never deliver fixed and final solutions but first test them with potential users.

Panel Session 4: Calibrating the Distribution of Agency in Human-Machine-Interaction

In his introduction to the fourth panel session **Werner Rammert** raised the question how to balance the cooperation of humans and objects. To approach this question he firstly described trends in the recent development of socio-technical constellations. According to Rammert technology becomes increasingly active, mobile and cooperative. Passive instruments and isolated, strongly coupled systems are replaced and superimposed by cooperating ensembles and open networks of learning and highly complex and loosely coupled chains of action. Secondly, Rammert developed a typology of agency levels of technical objects, i.e. passive, semi-active, pro-active, co-operative and trans-active objects. With the emergence of the advanced types of technical objects, he argued further, relations between people and objects change and move from the instrumental use of craft tools or machines to the interactive communication in which intelligent agents assist, offer services and profile users, thus, transforming the human-machine relations into more complex and contingent inter-activity. Thirdly, Rammert outlined levels of agency and their respective grades. 1) *Causality* on a continuum between short-time irritation and the permanent restructuring of action 2) *contingency* on a continuum between the selection of pre-selected and the self-generation of actions, and 3) *intentionality* on a continuum between the ascription of simple dispositions and the guidance by complex semantics. Finally he concluded that the emergence of distributed agency in socio-technical constellation implies the distribution of control. The consequence for design, according to Rammert, is to decide the following questions: How much agency should be assigned to the objects? How autonomous should be the networked systems? What should be the media and loci of control? Given the wide range of options, such as technically implemented control, self-monitoring, transparency for the user or regulatory institutions, Rammert recommended, to tune and test the interactivity before marketing final solutions.

Mireille Hildebrandt, lecturer for law and legal theory at the Erasmus University Rotterdam and senior researcher at the Institute of Law Science Technology and Society at Vrije Universiteit Brussel, contributed to the issue of the distributed agency in cooperating objects environments by informedly speculating about the legal implications of IBM´s vision of "autonomic computing". Hildebrandt explained that IBM claims autonomic computing to be the solution for the complexity that arises from the rise of networked environments. The visions entails the development of computer systems that are capable of self management, self configuration, self optimization, self healing and self protection in order to prevent a breakdown and to facilitate real time adaptive environments being able to cater to our inferred preferences without human intervention. In face of this vision Hildebrandt considered the challenges that emerge when it becomes impossible to attribute criminal liability to any node in an intelligent hybrid system which may require us to qualify the network as a whole as the responsible actor. Hildebrandt argues that in as far as artificial intelligence does not develop self-consciousness it lacks the capacity to reflect and this means that censure and punishment make no sense, unless they are understood as mere discipline. Next to this she explores the issue of technological normativity and discusses the way in which technological devices and infrastructures can constrain our actions in comparison to the way legal norms achieve this. Hildebrandt warns that we should think twice before introducing technological infrastructures that enable unaccountable consequences. She concludes that the legal-political implications of multi-agent intelligence at this point will be the need for democratic legitimization and the invention of new ways to organize democratic participation at an early stage of the introduction of new technologies.

Michael Decker, Vice Director of the Institute for Technology Assessment and System Analysis (ITAS) at the Research Centre Karlsruhe, presented the lessons learned from technology assessment (TA) of robotics in order to gain insights into cooperating objects as another field of emerging non-passive technology. Decker reported that robots are among the rare technical systems that have already been comprehensively described and discussed in terms of their possible construction and effects before actually being built. However, recent developments in robotics, Decker continued, make the replacement of humans in formerly untechnicized contexts more likely in the near future. In order to develop criteria to assess the replaceability of humans by robots in specific contexts of action an interdisciplinary expert group met monthly for intense discussion over a period of two years in a TA-project[9] coordinated by Decker. The group discussed issues of technical, economic, legal and ethical replaceability. Decker's presentation highlighted the findings concerning the issue of responsibility and liability: Who is liable for damage caused by a robot? Do robots require special equipment for "unexpected" encounters with laypersons? Is it necessary to prepare people for the possibility of such encounters? Are there additional aspects to be considered for "learning" robots? Do contexts exist in which the integration of robots should be excluded by modern societies, e.g. in the domains of geriatric care or the education of children? Decker reported that several recommendations were made regarding the issue of unpredictability of learning robots. Among others it was proposed to enable the robot user by technical means to take over responsibility for the robot action: The robot should indicate what it has identified as "worth to learn" and the robot user should need to explicitly accept this proposal, if the robot should learn that task. But Decker finally reminded that such transparent learning algorithms are, on the other hand, likely to cause problems which are rooted in one of the basic challenges of artificial intelligence: They might lack context awareness.

Panel Session 5: Managing Complexity in Socio-Technical Networks of Cooperating Objects and Humans

The presentation of **Johannes Weyer** dealt with hybrid systems, where human actors and non-human agents meet and interact. Weyer showed that the release of smart technology may lead to a transformation of society and consequently asked how social order emerges in hybrid systems. Discussing different sociological concepts, he identified two modes of governance: central control and decentralized self-organization. But, Weyer continued, smart technology allows to go beyond this traditional distinction. Referring to a case study on collision avoidance in aviation (and especially the mid-air collision at Überlingen in 2002), he showed that hybrid systems create new opportunities, but entail new risks as well, especially because of the new relation between man and (smart) machine. Weyer argued that the release of smart agents seems to intensify well-known problems of automation, especially if systems get out of control, and concluded that aviation is one of the societal fields, where experiments with new modes of

[9] *Robotik. Optionen der Ersetzbarkeit des Menschen*, Europäische Akademie Bad Neuenahr-Ahrweiler GmbH. TA-Nachricht zu dem Projekt unter: http://www.itas.fzk.de/deu/tadn/tadn993/deck99a.pdf.

governance currently take place that combine features of central control and decentralized self-organization.

Another complex system and the problems of its management were presented and discussed by **Leon Hempel**, researcher at the Center for Technology and Society at the Technical University Berlin. Hempel´s case study was the extensive CCTV [10] surveillance system operated by the Traffic Policing Enforcement Directorate of Transport of London. Given the number of several thousand surveillance cameras both deployed fixed at roadsides and mobile on public busses or in cars and vans of the Enforcement Directorate Hempel noted that the highly centralized system is already ubiquitous. Moreover, in the near future the surveillance systems of all London Transport services will be integrated into the Traffic Police Enforcement Directorate, including the CCTV systems of the Underground, the river services, the traffic congestion scheme etc. Given the convergence of these CCTV systems and, what is more, their convergence with other surveillance and monitoring technologies, such as tracking devices, location sensors and Geographic Information Systems Hempel coined the term the “enforcement assemblage” thus referring to Haggerty and Ericson (2000) who borrow Gille Deleuze´s notion of the “assemblage” in which traditional forms of hierarchic integration of individual components is being replaced by rhizomatic networks. Hempel showed that the CCTV network despite its ubiquitous and technologically sophisticated character is not necessarily fit for purpose and very difficult to manage. In particular learning effects of the environment challenge the static character of its main components. Responding to these problems often entails new management problems that contradict the original purpose.

[10] CCTV stands for *closed-circuit television* the British term for video surveillance.

Conclusion

This final chapter aims firstly to highlight and summarize central questions and key issues which were repeatedly mentioned and discussed in presentations and discussions of the workshop. Secondly, it will discuss the wide range of methodological approaches, their contributions and shortcomings. Finally, it will suggest to rethink design principles and to consider the social aspects of cooperating objects and related technologies. This new paradigm of socio-technical design directs towards a shaping of technology informed by computer and engineering sciences as well as social research.

Defining the Research Subject(s)

The problem and advantage that social researchers face when approaching the emerging technologies known as cooperating objects, ubiquitous computing or ambient intelligence is that they most often have to study pilot applications, application scenarios, concepts and visions rather than stable technical artifacts embedded into everyday life. The clear advantage is that social research has the opportunity to have a say, become involved into the process of design and shape technologies and thus the societies embracing these. On the other hand the obvious problem is that the subject of research is vague and hard to determine, and therefore resists empirical analysis and instead nurtures informed speculation.

In his concluding remarks Albert Kündig noted that the terms ubiquity and/or pervasiveness are often used without specifying to what they relate. While it hardly contested that they apply to the level of basic technology (hardware or software) and the basic data transport functions (network protocols such as IP, UDP or TCP), the labels ubiquitous and pervasive become problematic when talking about standard platforms which provide unified application programmers interfaces, or about the application layer that suggests cooperating objects with a rich functionality and universally accepted standards. In addition, Kündig reminded that technology assessment should focus on applications rather than on technology. Making judgments on the advantages and drawbacks of networked ubiquitous computing is only reasonable when the subject of reflection is clearly defined and limited to particular contexts.

However, to allow an assessment not only of very specific and unique applications but also at a more general level Kündig called for the development of clear taxonomies and typologies. As a good starting point he recommended the concepts for defining the degrees of autonomy and levels of agency as contributed by Rammert and Schulz-Schaeffer (2002).

Not Making Things but Making Sense of Things: In Search of Usefulness and Usability

“Not making things but making sense of things!” is the leitmotif of Matt Jones´ research at the Future Interaction Lab in Swansea. Jones, Kündig and others reminded that the seductive visions of scientists and engineers are not necessarily attractive and useful for John and Jane Doe. Ben Allouch showed that marketing departments and designers who currently develop AmI applications target a “creamy layer” who skillfully embraces new technologies. The demands and needs as well as the abilities and skills of these segments of the population are not necessarily the same as those of the less affluent, less techno-savvy people (not to speak about the poor and illiterate population of the world) who might be envisaged as users when investors, products and applications are in search of mass markets. Therefore developers should avoid charging such new technologies with extremely positive connotations which might at the end disillusion users and scare off customers.

Kündig rose the question what the “Model T” [11] of pervasive computing might be and recommended to learn from past “killer applications” such as the telephone, the personal computer and the World Wide Web. He gave the hint that all these cases leave the “tricky” problems associated with the application of these tools to the user – meaning that problems due to cultural or linguistic diversity, application-specific rules etc. are overcome by exploiting the still unmatched human cognitive and intellectual capabilities.

Protecting Privacy and Building Trust

Another issue that frequently came up throughout the workshop was, not surprisingly, the issues of privacy, data protection and trust. Current developments in computing direct towards the collection and processing of an increasing quantity of personal data and, what is more, are in search of new qualities of data (e.g. biometric identifiers extracted from the human body or very intimate data displaying emotions and thoughts). They therefore pose a serious challenge for efforts to protect privacy and personal data. However, it is often pointed out that among human rights privacy is perhaps the most difficult to define (e.g. Lyon 1994: 14-17). Even Warren and Brandeis´ classic and very basic definition of privacy as the “the right to be let alone” raises the questions when people and users wish to exercise this right and when not, and under which conditions they are willing to accept disturbance in exchange for economics or other benefits. It is clear that privacy in this very informal and personal sense is nothing fixed but is highly contingent upon the specific context. What people are willing to reveal about their multi-layered identity and self depends on their trust in and their knowledge about the addressee of this information.

[11] Here Kündig was referring to Henry Ford´s “Model T” which was the first car produced in assembly lines and of which 15 million units were sold between 1908 and 1927.

In networked ubiquitous computing environments data might be collected of even very simple and insignificant incidents that might be never forgotten by the hardware memories of huge databases, they could be combined, sorted and reinvented by sophisticated algorithms and transferred at a global scale to other entities for further processing for unknown purposes. It is obvious that such complex multi-lateral systems of data processing resist attempts (not only by the common user) to know and understand their underlying purposes and rationales. Given this it seems very difficult to request users to make informed decisions about revealing their personal data and to generate trust in these new systems. And even if opt-in decisions are offered the multitude and complexity of choices in smart environment might simply overwhelm the users.

Besides traditional approaches to adapt data protection legislation to the new challenges other solutions for these problems were discussed at the workshop: Tentative concepts were presented such as "transparency enhancing technologies" which unveil how options are offered and, thus, enable a user response, or "ambient law" which inscribes legal requirements (such as the minimization of data) into technology and operation procedures. To reduce the complexity of decision making it was proposed to make systems simple and enable users to choose pre-defined privacy profiles which can be automatically cross-checked when entering a new environment of ambient intelligence or even to simply offer non-technical solutions. However, it became clear that the development of future applications cannot be left to the market alone because, as for instance Ben Allouchs presentations showed, permanent privacy violations are likely when suppliers pretend to offer trustworthy applications being in fact invasive only to generate their markets. While ethical and legal considerations might be the starting points to protect privacy and build trust in smart environments, questions of how to adequately communicate information about the privacy implications of applications and how to enable different types of user groups to make a deliberate choice about the fate of their data requires more than that and should also be part of design considerations.

Distributing and Locating Responsibility and Liability

An issue partly overlapping with privacy and trust that draw the attention of the workshop was the changing nature of responsibility and liability in socio-technical environments of distributed agency. It was consensus among the experts that it will become impossible to assign responsibility for faults or malfunctions to individual human or technical components of the extensive networked systems of cooperating objects and related technologies. Though Hilty pointed out that the increasing capability to log and track activities in such systems could help to reconstruct events in the aftermath of a possible disaster, Hildebrandt's and Weyer's case study of the plane crash in Überlingen showed that disasters might occur even when each component is working properly if different governance regimes interfere.

From a legal perspective a simple solution to the problem could be to attribute liability to service providers or users and thus urge them to cautiously select their applications. Decker, on the other hand, showed that the solution to make users responsible for their learning robots might cause new problems: The safeguard to request decisions by users regarding learning algorithms might, on the one hand, help to make their actions transparent and calculable, while limiting a key function of learning robots, i.e. context awareness. What is needed is a careful assessment of how to distribute agency in human-machine-interaction. Fair and reasonable decision about this issue will be highly contingent upon context and application and therefore require detailed research.

Bridging the Digital Divide and Being Sensitive to Digital Discrimination

While Pias already mentioned the challenge to bridge the digital divide in terms of access of all sexes, generations, classes and geographical areas to ICT at the very beginning, another issue touching the broader question of social justice came up in the course of the workshop. Digital discrimination, the automated social sorting and prioritizing of user preferences and needs, was demonstrated by Lindner when he gave the example of two users with different preference for lighting or temperature entering a room in a smart building. Given such as situation the system steering the relevant conditions will be required to make a decision: It can opt either for the lower or the higher temperature, or it can opt for a compromise found in between the two user preferences with both of them eventually feeling uncomfortable.

While the example might be trivial it illustrates the general problem and it is clear that scenarios with more serious implications for the users can be envisioned. Though the problem of right choice itself is not generated by the smart home but by different user preferences, the automation of environmental adaptation might hinder the dynamic negotiation between the users. Thus, visions of social relations, status and power that are intentionally or unintentionally inscribed by engineers and software programmers into design and code might be cemented and petrified over time and space (cf. Lyon 2003; Graham & Wood 2003). As these issues are closely related to issues of responsibility it is again serious research that should inform decision making and design.

Contributing to Ecological Sustainability

Several presentations addressed the issue of sustainability – with contradictory scenarios. Pias talked about the promises of ubiquitous computing to help saving energy, water and other essential resources. Hilty noted that energy consumption might rapidly increase in face of the rising power demand for network servers and other infrastructures that are supposed to be on(line) 24 hours a day at seven days a week. Furthermore, the spread of millions of very small components or devices might result in the inevitable diffusion of smart but toxic dust causing an irreversible loss of resources and serious environmental pollution. This scenario would be the culmination of what was described by the economist Nicholas Georgescu-Roegen as the law of entropy in economical process. If and how ideas of modular design and self-healing or redundant sensors will contribute to prevent such undesirable scenarios is a question for further research.

Methodological Challenges

Many methodological approaches to study and assess the social aspects and implications of cooperating objects and related technologies have been presented in the course of the workshop: scenario building, expert interviews with marketing people, developers and users, media analyses and ethnographic observation. The networked character of the emerging technologies at stake and the problems to limit analyses pose a serious challenge to traditional methods of TA and technology studies.

Studies of cooperating objects technologies and applications demand a multi-method approach combining instruments from historical analyses, laboratory studies, user surveys and forecast. Each method has its advantages and drawbacks: For instance, scenario building – even if the scenarios are supposed to be realistic and likely – means to reduce the complexity of a possible future and therefore poses the threat to miss crucial issues. For expert and user interviews the selection of the interviewees is of crucial importance in particular when used as an oracle to forecast future developments of make choices about technology to be implemented. Ethnographic observations could make an important contribution for testing and tuning pilot applications, as Dan Shapiro showed, but they need an actual test case which is often missing. This eventually leads us again to scenario building tools despite their shortcomings. The right choice of methodology is depending on the respective application and field of research.

Rethinking Design Principles

Many speakers have mentioned that design paradigms developed in the context of ubiquitous computing and AmI do not meet the purpose of particular applications. Visibility was mentioned as being of crucial importance for some devices to satisfy demands for representative aesthetics and as essential for CCTV cameras to deter certain types of behavior. The need to validate information and correct functioning of a technical system in emergency situations – activating empowerment rather than seductive convenience, as Rammert put it – challenges the paradigm of peripheral operation but claims for tangible, physically present technology.

To neglect such issues might result on the one hand in the development of useless products and applications which simply fail to generate a market and finally prove as a waste of money. On the other hand such ignorance might turn out as user nightmares when, for instance, applications are imposed on people in a top-down approach by technophile managers dazzled by spin doctors of the supplying companies.

Identifying the areas where it is crucial to choose between competing design principle and finding the balance between them in order to meet real user needs and improve human life instead of revolutionizing it into confusion is therefore a serious challenge for the future development of cooperating objects and related technologies. Mastering this challenge will also need sociological and anthropological rather than simply technical expertise. Only by trying to understand these different perspectives we will be able to see where we are heading and how new socio-technical constellations might evolve. Kündig noted in his concluding remarks that this is a prerequisite for the success of new technologies because the past has shown that wishful thinking alone does not suffice: Potential users must be convinced that behind all marketing hype there are people who know about the pros and cons, and use their knowledge in proper socio-technical design.

References

- Graham, Stephen and David Wood (2003): Digitizing Surveillance. Categorisation, Space, Inequality, in: *Critical Social Policy*, Vol. 23, Nr. 2, pp. 227-248.
- Greenfield, Adam (2006): *Everyware. The Dawning Age of Ubiquitous Computing*, Berkeley: New Riders.
- Haggerty, Kevin and Richard V. Ericson (2000): The surveillant assemblage, in: *British Journal of Sociology*, Vol. 51, Nr. 4, December 2000, pp. 605-622.
- Lyon, David (1994): *The Electronic Eye. The Rise of Surveillance Society*, Minneapolis: University of Minnesota Press.
- Lyon, David (ed.) (2003): *Surveillance as Social Sorting. Privacy, Risk, and Digital Discrimination*, New York: Routledge.
- Rammert, Werner and Ingo Schulz-Schaeffer (eds.) (2002): *Können Maschinen handeln? Beiträge zum Verhältnis von Mensch und Technik*, Frankfurt/Main: Campus.
- Weiser, Mark (1991): *The Computer for the 21st Century*, Scientific American Ubicomp Paper, online: http://www.ubiq.com/hypertext/weiser/SciAmDraft3.html, accessed: November 5, 2006.
- Weiser, Mark & John Seeley Brown (1995): *Designing Calm Technology*, online: http://www.ubiq.com/hypertext/weiser/calmtech/calmtech.htm, accessed: November 5, 2006.

Annex

Workshop Program

Wednesday | November 1, 2006

1:00 pm | Introduction

- Prof. Dr. Adam Wolisz
  Telecommunication Networks Group, Institute for Telecommunication Systems, Technical University Berlin
  Welcome Note: Introducing "Embedded WiSeNts" and Aim of the Workshop

- Prof. Dr. Werner Rammert
  Centre for Technology and Society, Technical University Berlin
  Rationale and Organization of the Workshop

- Dr. Marcelo Pias
  Computer Laboratory, Digital Technology Group, University of Cambridge
  Cooperating Objects and Wireless Sensors: The Impact of the Technical Visions on Society. A Framework for Discussion

2:00 pm | Panel 1: Grand Challenges. A Review of Recent Surveys

- Prof. em. Dr. Albert Kündig
  Swiss Federal Institute of Technology Zurich and Member of TA-Swiss Steering Committee
  Incapacitated Cyborgs? Approaches to the Systematic Assessment of Pervasive Computing

- Prof. Dr. Lorenz Hilty
  Department for Technology and Society, EMPA St. Gallen
  Social and Environmental Aspects of Pervasive Computing

- Prof. Dr. Ernst Andreas Hartmann
  Head of Socio-Economic Section, VDI/VDE Innovation + Technik GmbH
  Ubiquitous Computing - Developments and Impacts

3:30 pm | Coffee Break

4:00 pm | Panel 2: Governing Risk, Privacy and Trust in Cooperating Objects Environments

- Dr. Martin Meints
  Independent Center for Privacy Protection Schleswig-Holstein, Kiel
  Technical Concepts of Ubiquitous Computing and Potential Legal Consequences
- Stephan J. Engberg
  Priway - Security in Context
  (This presentation was cancelled as weather conditions hindered Engberg to participate)

Security and Dependability in a World of Ubiquitous Computing. From Identification to Context Adaptable Recognition

- Dr. Ralf Lindner
  Fraunhofer Institute for System and Innovation Research, Karlsruhe
  Trust in a World of Ambient Intelligence

5:30 pm | End of Day I

7:30 pm | Workshop Dinner

<u>Thursday | November 2, 2006</u>

9:00 am | Panel 3: Assessing User Expectations and Anticipating Practices of Use

- Somaya Ben Allouch
  Department of Communication Science, University of Twente
  Ambient Intelligence in Private Spaces. The Confrontation of Design and Use

- Prof. Dr. Dorothea Kübler
  Microeconomics, Faculty of Economics and Management, Technical University Berlin
  Ubiquitous Computing and Economic Experiments - A Perspective

- Dr. Matt Jones
  Future Interaction Technology Lab, Department of Computer Science, Swansea University
  Mobile Interaction Design

- Prof. Dr. Dan Shapiro
  Sociology Department , Lancaster University
  Designing Ubiquitous Computing: Palpability and Participation

11:00 am | Brunch

12:00 am | Panel 4: Calibrating the Distribution of Agency in Human-Machine-Interaction

- Prof. Dr. Werner Rammert
  Center for Technology and Society, Technical University Berlin
  Distributed Agency and Control in Socio-Technical Constellations: How to Balance the Cooperation between Humans and Objects?

- Dr. Mireille Hildebrandt
  Center for Law, Science, Technology and Society Studies, Free University Brussels
  Distributed Agency and Legal Responsibility. Speculations about the Legal Implications of Autonomic Computing

- PD Dr. Michael Decker
  Institute for Technology Assessment and System Analysis, Karlsruhe

Autonomous Controlling of Sensors and Actors. Lessons learned from Human-Robot-Interaction

1:30 pm | Panel 5: Managing Complexity in Socio-Technical Networks of Cooperating Objects and Humans

- Prof. Dr. Johannes Weyer
  Sociology of Technology, Department for Economics and Social Science, University Dortmund
  Managing Complexity. Risks and Challenges of Hybrid Systems

- Dr. Leon Hempel
  Center for Technology and Society, Technical University Berlin
  Organizing (Visual) Surveillance: CCTV, Image Processing and Data Management in Public Transport

2:30 pm | Concluding Remarks and Final Discussion

- Prof. em. Dr. Albert Kündig
  Swiss Federal Institute of Technology Zurich and Member of TA-Swiss Steering Committee

3:30 pm | End of Day II

List of Participants

Name	Institution	Email
Somaya Ben Allouch	Department of Communication Science, University of Twente	s.benallouch@utwente.nl
Andras Budavari	Center for Technology and Society, Technical University Berlin	andrasbudavari@gmx.de
PD Dr. Michael Decker	Institute for Technology Assessment and System Analysis, Karlsruhe	Michael.Decker@itas.fzk.de
Laura Marie Feeney	Computer and Network Architecture Laboratory, Swedish Institute of Computer Science	lmfeeney@sics.se
Michael Hahne	Center for Technology and Society, Technical University Berlin	hahne@ztg.tu-berlin.de
PD Dr. Ernst Andreas Hartmann	Socio-Economic Section, VDI/VDE Innovation + Technik GmbH	Hartmann@vdivde-it.de
Dr. Leon Hempel	Center for Technology and Society, Technical University Berlin	hempel@ztg.tu-berlin.de
Prof. Dr. Mireille Hildebrandt	Center for Law, Science, Technology and Society Studies, Free University Brussels	hildebrandt@frg.eur.nl
Prof. Dr. Lorenz Hilty	Department for Technology and Society, EMPA St. Gallen	Lorenz.Hilty@unisg.ch
Mario Hoffmann	Fraunhofer SIT	mario.hoffmann@sit.fraunhofer.de
Dr. Matt Jones	Future Interaction Technology Lab, Department of Computer Science, Swansea University	always@acm.org
Corinna Jung	Center for Technology and Society, Technical University Berlin	jung@ztg.tu-berlin.de
Tom Kramer	Center for Technology and Society, Technical University Berlin	tom@zughafen.de
Prof. Dr. Dorothea Kübler	Microeconomics, Faculty of Economics and Management, Technical University Berlin	d.kuebler@ww.tu-berlin.de
Prof. em. Dr. Albert Kündig	Swiss Federal Institute of Technology Zurich and TA-Swiss Steering Committee	kuendig@tik.ee.ethz.ch
Dr. Eva Maria Lijding	Embedded Systems, University of Twente	M.E.M.Lijding@ewi.utwente.nl
Dr. Ralf Lindner	Fraunhofer Institute for System and Innovation Research, Karlsruhe	Ralf.Lindner@isi.fraunhofer.de
Gaia Maselli	CS Dept., Rome University "La Sapienza"	maselli@di.uniroma1.it
Dr. Martin Meints	Independent Center for Data Protection Schleswig-Holstein, Kiel	ld102@datenschutzzentrum.de
Martin Meister	Center for Technology and Society, Technical University Berlin	meister@ztg.tu-berlin.de
Dr. Marcelo Pias	Computer Laboratory, Digital Technology Group, University of Cambridge	marcelo.pias@cl.cam.ac.uk

Irina Piens	Telecommunication Networks Group, Institute for Telecommunication Systems, Technical University Berlin	piens@prz.tu-berlin.de
Jörg Potthast	Social Science Research Center Berlin	potthast@wz-berlin.de
Prof. Dr. Werner Rammert	Center for Technology and Society, Technical University Berlin	werner.rammert@tu-berlin.de
Dr. Kay Römer	Institute for Pervasive Computing, ETH Zurich	roemer@inf.ethz.ch
Silvia Santini	Institute for Pervasive Computing, ETH Zurich	santinis@inf.ethz.ch
Fabia Schäufele	Institute for Sociology, Technical University Berlin	fabia.schaeufele@tu-berlin.de
Dr. Ingo Schulz-Schaeffer	Institute for Sociology, Technical University Berlin	schulz-schaeffer@tu-berlin.de
Prof. Dr. Dan Shapiro	Sociology Department , Lancaster University	d.shapiro@lancaster.ac.uk
Jonas Spengler	Institute for Sociology, Technical University Berlin	jonas.spengler@tu-berlin.de
Eric Töpfer	Center for Technology and Society, Technical University Berlin	toepfer@ztg.tu-berlin.de
Rene Tuma	Institute for Sociology, Technical University Berlin	rene_tuma@web.de
Prof. Dr. Johannes Weyer	Sociology of Technology, Department for Economics and Social Science, University Dortmund	johannes.weyer@uni-dortmund.de
Prof. Dr. Ing. Adam Wolisz	Telecommunication Networks Group, Institute for Telecommunication Systems, Technical University Berlin	awo@ieee.org

Short Bios of Invited Speakers in Alphabetical Order

Somaya Ben Allouch is a PhD candidate at the New Media and Communication group at the University of Twente, the Netherlands. Her research focuses on the design and use of (new) media and ICT. In her PhD project she looks specifically at the design and use of ambient intelligent applications.

Michael Decker, PD Dr rer. nat., studied physics (minor subject economics) at the university of Heidelberg, 1992 diploma, 1995 doctorate with a dissertation on temperature measurements in high pressure combustion by laser-techniques at the university of Heidelberg, 1995-1997 scientist at the German Aerospace Center (DLR) in Stuttgart, 1997-2002 member of the scientific staff of the Europäische Akademie GmbH. He was manager of the project "Robotics. Options of the replaceability of human beings" and the study group "Miniaturization and Material Properties". He coordinated the EU-Project TAMI (Technology Assessment in Europe. Between Method and Impact). Since 2003 he is member of the scientific staff and since February 2004 vice-director of the Institute for Technology Assessment and System Analysis (ITAS) at the Research Centre Karlsruhe, 2006 habilitation at the faculty of applied sciences of the university of Freiburg with a study on interdisciplinary research for technology assessment. He chairs the coordination team of the German-speaking Network Technology Assessment. Main research areas: TA of robotics, pervasive computing and nanotechnology, comparison of TA-methods and interdisciplinary research for policy advice.

Stephan J. Engberg is member of the Strategic Advisory Board of the EU ICT Security & Dependability Taskforce and as such involved in roadmapping and writting the Recommendations Report. He is founder of Priway and the spin-off company RFIDsec based on a private research project "Privacy Highway" focussing on ways to reconcile the security requirements in both ambient and integrated digital networks. Priway is partner in a IST IP project HYDRA on Networked Embedded Systems and has been involved in EU Security and Identity Roadmapping since pre-FP6 and a range of workshops and conferences such as Trust in the Net, SWAMI, Public Services Summit, NATO Advanced Research Workshop and the upcomming EU-US Cybertrust Workshop on System Dependability & Security. Engberg holds an M.Sc. in Business Adminstration and Computer Science at Copenhagen Business School together with studying International Strategy at Londong Business School. He has been lecturing at Copenhagen Business School and the IT University for a number of years on Trust Socio/Economics and Context Security especially in mobile environments. He is dedicated to the work of designing Empowerment & Dependability into ICT systems for the purpose of balanced trustworthiness.

Ernst Andreas Hartmann, Prof. Dr., is Head of the Socio-Economic Section of the Association of German Engineers' VDI/VDE Innovation + Technik GmbH and Acting

Professor for Psychology at the Department for Ergonomics and Work Science at the University of Magdeburg.

Leon Hempel, Dr., studied German, Comparative Literature and Political Science at the Technical University Berlin. After his graduation in 1999 he started to work at the Centre for Technology and Society. At the Center he was involved in the EU-funded projects TeleCityVision (2000-2001) and Urbaneye (2001-2004) that analysed the impacts of ICT for urban changes, respectively video surveillance in public accessible space. He finished his PhD thesis in 2004 and published in “Bild – Raum – Kontrolle” (with Jörg Metelmann, Frankfurt/Main: Suhrkamp, 2005), an anthology about video surveillance. Hempel currently evaluates CCTV systems of several transport systems in London and Berlin.

Mireille Hildebrandt, Dr., teaches law and legal theory at Erasmus University Rotterdam. In 2002 she wrote her PhD thesis in the field of criminal procedure and legal philosophy, with special focus on issues of epistemology. From 2002 she has been seconded as senior researcher to the institute of Law Science Technology and Society at the Vrije Universiteit Brussel to participate in a multidisciplinary research project on the relationship between law, technology and democracy, supervised by Serge Gutwirth, Bruno Latour and Isabelle Stengers. She is involved in the European Network of Excellence on the Future of Identity in Information Society (FIDIS) as a coordinator for the subject of profiling technologies. From 2003-2006 she also taught comparative legal traditions of the world in the LLM Program on International Legal Cooperation at the Vrije Universiteit Brussel.

Lorenz Hilty, Prof. Dr. rer. nat., head of the Technology and Society Lab at the Swiss Federal Laboratories for Materials Testing and Research (Empa) and lecturer at the University of St. Gallen (HSG), studied Computer Science and Psychology at Hamburg University and received his Ph. D. in 1991. In 1998, he became a Professor for Information Systems at the University of Applied Sciences Northwestern Switzerland. In 2000, he initiated the research program "Sustainability in the Information Society" (SIS) at Empa, co-funded by the ETH board (2001-2005), from which the Technology and Society Lab emerged in 2004. Lorenz Hilty is the vice chair of the Technical Committee "Computers and Society" of the International Federation for Information Processing (IFIP TC 9) and member of the board of the Swiss Informatics Society (SI). He is the author of many influential publications in the field of environmental and social impacts of ICT, including the study "The Precautionary Principle in the Information Society", commissioned by the Swiss Center for Technology Assessment (TA-SWISS).

Matt Jones, Dr., has recently moved from New Zealand to Wales where he is helping to set up the Future Interaction Technology Lab at Swansea University. He has worked on mobile interaction issues for the past ten years and has published a large number of articles in this area. He is the co-author (with Gary Marsden) of Mobile Interaction Design (John Wiley & Sons, 2006). He has had many collaborations and interactions with handset and service developers including Microsoft Research, Orange, Reuters, BT Cellnet, Nokia and Adaptive Info; and has one mobile patent pending. He is an editor of the "International Journal of Personal and Ubiquitous Computing" and on the steering committee for the "Mobile Human Computer Interaction" conference series.

Dorothea Kübler, Prof. Dr., is Chair in Microeconomics at the Faculty of Economics and Management of the Technical University Berlin. She studied Economics at the University of Konstanz and the Free University Berlin, and finished her PhD thesis at the Humboldt University Berlin in 1997. After fellowships and research visits in Berkeley, Bergen and Harvard she became Assistant at the Institute for Economic Theory of the Humboldt University Berlin where she submitted her habilitation in 2003. Her main research interests are game theory, information economics, and psychology and economics. She is currently leading the research project "Strategic uncertainty in experimental games" funded by the German Science Foundation DFG.

Albert Kündig, Prof. em. Dr., received MS degrees from Swiss Federal Institute of Technology ETH Zurich (Electrical Engineering) and Harvard University (Applied Physics) in 1961 and 1964 resp., and a PhD from ETH in 1974. At the former Swiss PTT research lab, he participated in an effort to build one of the first experimental digital switching systems. From 1972 to 1983, he took gradually more responsibilities in the Swiss PTT research division. Kündig joined the ETH Department of Information Technology and Electrical Engineering as Professor for Systems Engineering in 1983. His research interests centered on multimedia communication in high performance networks, and design and development methodology for real-time highly dependable systems. Albert Kündig retired from ETH in 2002, however continuing with research in the history of technology and studies regarding the impact of information technology on society, economy and culture. His association with the Technology Assessment board of the Swiss Council for Science and Technology reflects his keen interest in this field.

Ralf Lindner, Dr., joined the Fraunhofer Institute for Systems and Innovation Research (ISI) as a project manager and senior scientist at the department of Emerging Technologies in 2005. He received his degree in political science and economics from the University of Augsburg, completed graduate work at the University of British Columbia (Vancouver) and post-graduate studies at Carleton University (Ottawa). His doctoral dissertation, which he completed at the department of political science at the University of Augsburg, focuses on the application and integration of digital networks in the communication strategies of intermediary organizations in North America. He is particularly interested in the diffusion processes of ICTs, emerging and future trends of media convergence and ubiquitous networks. Additional research interests include cognitive policy analysis, epistemic communities and processes of policy learning. Among his projects at the Institute are SWAMI (Safeguards in a World of Ambient Intelligence) and FAZIT (Foresight for future media and ICT sector trends).

Martin Meints, Dr., studied chemistry and computer science at the University Kiel. He worked in various enterprises and public organizations as IT project manager and in technical management functions. Main focus of his latest work was preparation and implementation of security concepts for large private networks (LAN and WAN) and integrated mobile computing solutions basing on the methodology of the Baseline Protection Manual from BSI, the German Federal Office for Information Security. Since 2004 researcher for the Independent Centre for Privacy Protection Schleswig-Holstein (ICPP); he is mainly involved in the project "FIDIS - Future of Identity in the Information Society".

Marcelo Pias, Dr., has been a Research Associate in the Computer Laboratory at the University of Cambridge (UCL) since Sept. 2004. In his prior post doctoral position at Intel Research Laboratories Cambridge, he worked on decentralized P2P systems and wireless sensor networks. He obtained a BEng in Computer Engineering from FURG (Brazil) in 1999 and a PhD degree in Computer Science from UCL in February 2004. He is involved in two wireless sensor projects: SESAME - SEnsing for Sport And Managed Exercise is a UK EPSRC project that aims at tracking the performance of athletes in sports events, and the EU funded Embedded WiSeNts project is preparing a research roadmap in the area of wireless sensor systems for the EC.

Dan Shapiro is Professor of Sociology at Lancaster University in the United Kingdom. He is co-author of five books and many papers. He has a longstanding track record of research in the ethnographic study of social practice to inform the design of information systems, in participatory design and evaluation with end users, and in interdisciplinary theory for information system design and spatial computing. He has been a principal researcher on a succession of EU funded projects since 1995 on computer-supported cooperative work, collaborative working environments, spatial computing, and ambient computing.

Werner Rammert, Prof. Dr., is Professor for Sociology and Technology Studies at the Technical University of Berlin and Speaker of the Centre for Technology and Society since 1999/2000. After his degree in Sociology he served as Research Fellow and Assistant at the Universities of Bochum and Göttingen and Lecturer in Sociology at Bielefeld. Rammert passed his PhD in 1981. His Habilitation in Sociology was granted in 1988. He was appointed to the position of a Full Professor for Sociology at the Free University Berlin in 1991. Later he changed to the Technical University of Berlin, where is Professor of Sociology and Technology Studies. Rammert held guest lectures at the universities of Vienna, Bradford, Birmingham, Paris, Montreal, Trondheim, Basel, Zurich and Copenhagen, acted as research director of various programs and co-edits the yearbook “Technology and Society” since 1982. Special areas of research interest are the assessment of information and communication technologies, innovation and organizational learning and the newly created research field of Socionic, the inquiring and modeling of artificial societies.

Johannes Weyer, Prof. Dr., is Professor for Sociology of Technology at the Department for Economics and Social Science of the University Dortmund. He studied at the University Marburg and made his doctorate in 1983 with a dissertation on the history of German sociology after 1945. From 1984 to 1999 he was assistant Professor at the University of Bielefeld in the field of science and technology studies. In 1991 he completed his habilitation with a study on space policy in Germany from 1945 to 1965. After three years in a consultant firm for e-logistics he was appointed Professor in Dortmund in 2002. His main research interests are: social shaping of technology, technology policy, network analysis, and innovation management in highly automated systems, especially in the field of transportation and aerospace. He also has written a biography of the German space pioneer Wernher von Braun.

Adam Wolisz, Prof. Dr., (Diploma in engineering, 1972, Doctoral Degree, 1976, Habilitation 1983 - Silesian University of Technology, Gliwice) works since 1980 on computer networks and distributed systems. He has been with Polish Academy of Sciences (until 1990), and later with the Research Institute GMD-Fokus in Berlin (1990-1993). Since 1993 he has joined the Technische Universität Berlin (TUB) where he is chaired Professor for Telecommunication Networks and since 2001 Executive Director of the Institute for Telecommunication Systems. He has served as the Dean of the Faculty of Electrical Engineering and Computer Science in the period 2001- 2003. Since summer 2005 he is also Adjunct Professor at the Dept. EE&CS, University of California, Berkeley. His research interests are in architectures and protocols of communication networks. Recently he is focusing mainly on wireless/mobile networking and sensor networks.

References

[1] Andrew Rice. Dependable Systems for Sentient Computing - PhD Thesis. Technical Report To appear as a technical report of the Computer Laboratory, University of Cambridge, December 2006.

[2] TAUCIS Consortium. Technology Assessment of Ubiquitous Computing and Informational Self-Determination (TAUCIS). 2006.

[3] IST Advisory Group (ISTAG). ISTAG REPORT on Orientations for Work Programme in FP7. Technical report, European Commission, June 2006.

[4] IST Advisory Group (ISTAG). Shaping Europe's Future through ICT. Technical report, European Commission, March 2006.

[5] Jrgen Bohn and Vlad Coroama and Marc Langheinrich and Friedemann Mattern and Michael Rohs. *Social, Economic, and Ethical Implications of Ambient Intelligence and Ubiquitous Computing*, pages pp. 5–29. Springer-Verlag, 2005.

[6] K. Pister. Sensor Networks in 2010. Technical report, University of California Berkeley, 2001.

[7] J. O. Kephart and D. M. Chess. The Vision of Autonomic Computing. *IEEE Computer Magazine*, 36(1):41–50, January 2003.

[8] Mark Weiser. The computer for the 21st century. In *ACM SIGMOBILE Mobile Computing and Communications Review - Special issue dedicated to Mark Weiser*, pages 3 – 11, 1999.

[9] Pedro Jose Marron and Daniel Minder and the Embedded WiSeNts Consortium. *Embedded WiSeNts Research Roadmap*. Logos Verlag Berlin, November 2006.

[10] Peter Gabriel et al. *Pervasive Computing: Trends and Impacts*. SecuMedia Verlag, Ingelheim, 2006.

[11] TA-Swiss. *The Principle of Precaution in an Information Society : Pervasive Computing and its Effects on Health and on the Environment*. 2006.