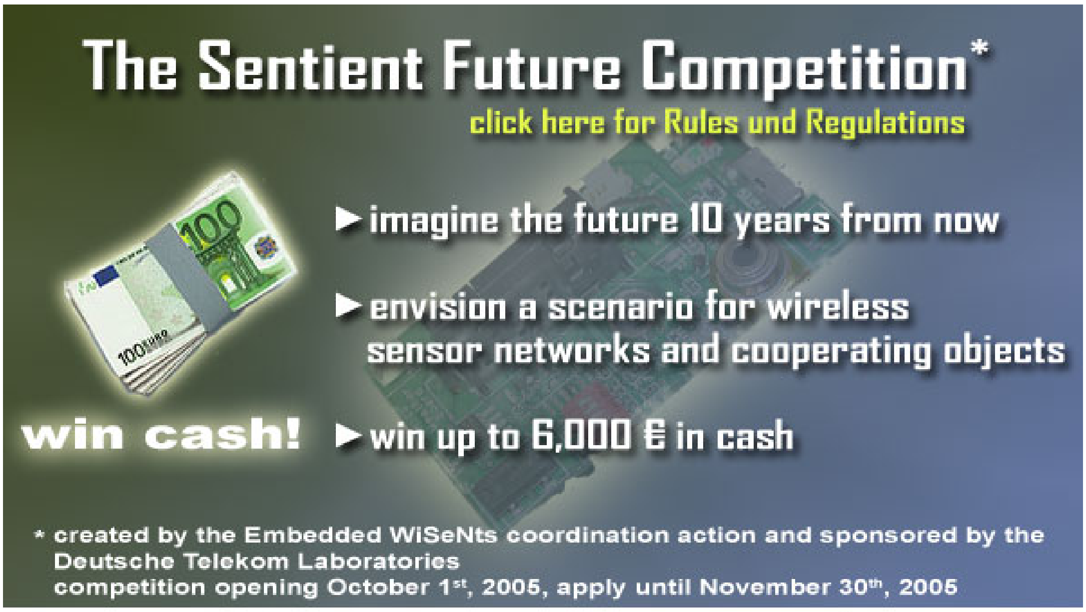
The Sentient Future Competition

Envision a scenario for the use of Wireless Sensor Networks for Cooperating Objects

– 10 years from now –

Winners and Highly Commended Entries



Deutsche Telekom Laboratories
An-Institut der Technischen Universität Berlin

Embedded WiSeNts

Information Society Technologies

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Sentient Future Competition: Introduction

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1. OVERVIEW

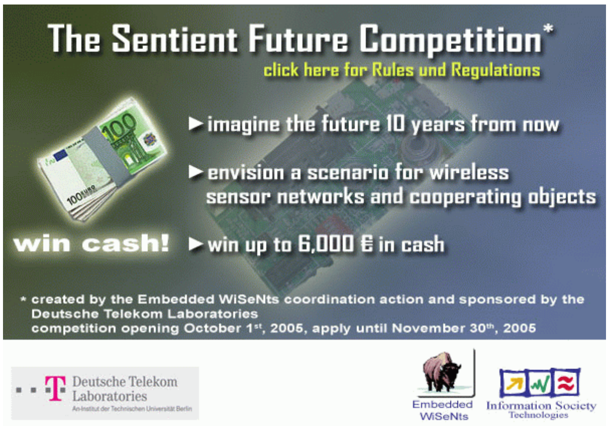
In the near future many parts of our environment will include a plethora of sensor nodes - very small, inexpensive computers equipped with devices for sensing or receiving information about the physical world in which they are located and performing simple actions. Sensor nodes communicate with each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

The European-funded project Embedded WiSeNts[1] is preparing a research roadmap in the area of Cooperating Objects to identify important research problems that need to be addressed. To guide this roadmap preparation, we are required to foresee the most promising visions for innovative applications.

To shed light on this, the Sentient Future Competition challenged the members of the public to find interesting applications that we can expect to have in 10 years from now once all the basic CO technologies are in place. The competition, an initiative of the Embedded WiSeNts with sponsorship of Deutsche Telekom Laboratories[2], was launched on the 1^{st} Oct 2005 and the results were announced on the 18^{th} Jan 2006.

The judges and reviewers faced a tremendous challenge to evaluate the high quality application scenarios received. All entries were rigourously reviewed by three members of a panel composed of 24 reviewers, who prepared a short list. The shortlisted scenarios were then carefully reviewed by all members of the distinguished judging panel who made the final decision including the first prize winner, second and third runner-ups along with 9 commended applications. The entries were evaluated against the criteria of originality of concept, innovation and technical progress, and impact - social, economic and environmental. This volume contains the winning entries and 7 of the highly commended applications.

[1] http://www.embedded-wisents.org
[2] http://www.telekom.de/laboratories



The Embedded WiSeNts Sentient Future Competition Judging Panel is happy to announce the final results as follows. Prizes have been awarded in a special session of EWSN 2006.

2. WINNERS

1^{st} Prize: € 6000

Large Scale Body Sensing for Infectious Disease Control
Markus Endler (Department of Informatics, Pontifica Universidade Catolica do Rio de Janeiro, BR).

2^{nd} Prize: € 3000

BIN IT! The Intelligent Waste Management System
David Schoch (Student of Geography, University of Zurich, Switzerland), Matthias Sala (Student of Computer Science, ETH Zurich, CH).

3^{rd} Prize: € 1000

Vision of Congestion-Free Road Traffic and Cooperating Objects
Ricardo Morla (PhD student in Computer Science, Lancaster University and Researcher, INESC Porto, PT).

3. HIGHLY COMMENDED ENTRIES

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

A Day in the Life of a not too Distant Future
Phillip De Caux (University of Liverpool, UK).

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

Father in Womb
Tiago Camilo, André Rodrigues, Jorge Silva, F. Boavida (University of Coimbra, PT), Eduardo Sá (Superior Institute of Applied Psychology, PT).

LocuSent - locust control
Milo Lavén (ArtCore Stockholm, SE).

PerSens: Personality Sensors
Zinaida Benenson, Mesut Güneş, Martin Wenig (RWTH Aachen University, DE).

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

SmartSoot
Patrick Andrews (Break-step Productions Ltd, UK).

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

4. 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

5. REVIEWERS

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6. ACKNOWLEDGMENTS

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

Sentient Future Competition: Winners

Sentient Future Competition
Large scale body sensing for Infectious Disease Control

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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.

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Sentient Future Competition: *BIN IT!* – The Intelligent Waste Management System

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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.

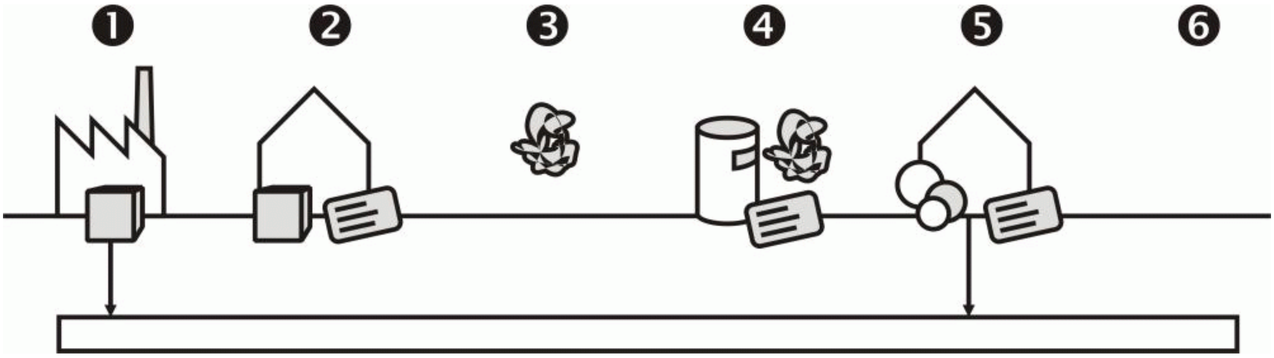

Figure 2: Cycles within the intelligent waste management system.

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.

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

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

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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.

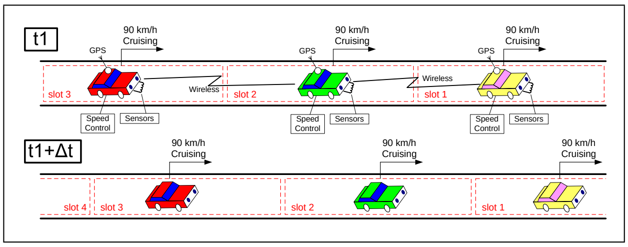

Figure 1: Example of a single lane with moving virtual vehicle slots. Notice how each slot moves forward with time at the recommended speed of the lane (90 km/h). Notice also that the vehicles communicate with each other, determine their position, sense their environment (e.g. proximity detection), and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

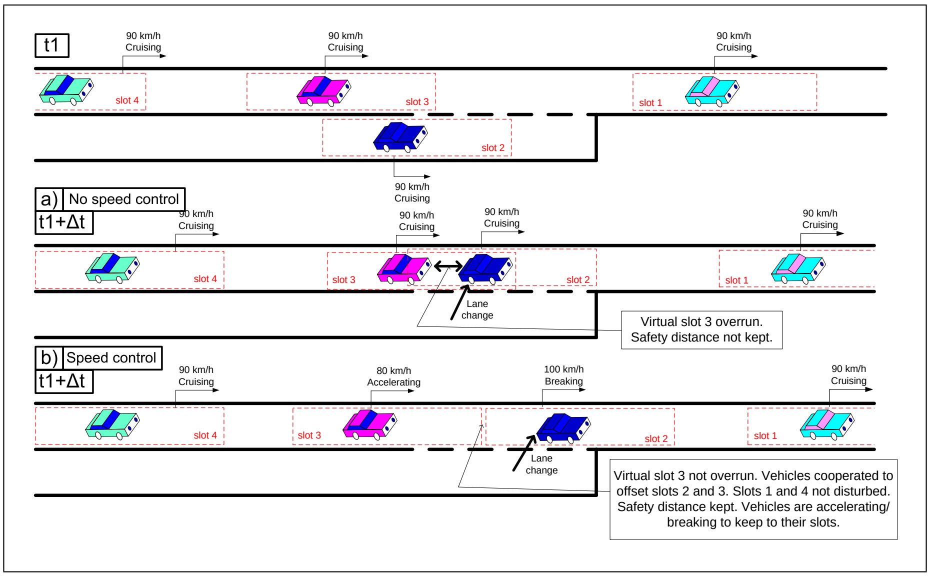

Figure 2: Example of merging lanes a) without and b) with vehicle cooperation.

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.

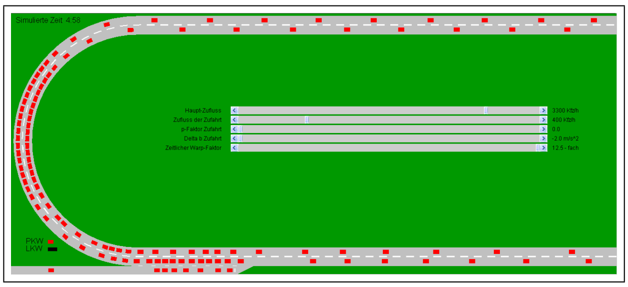

Figure 3: Typical scenario provided in the original simulator source code. Notice the congestion.

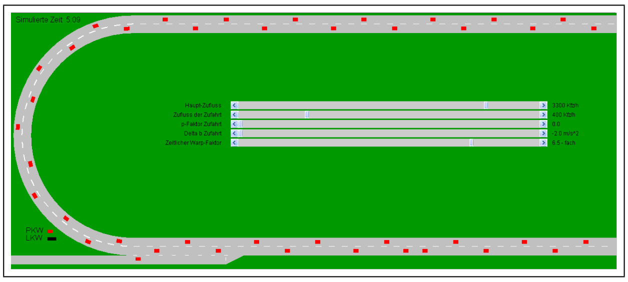

Figure 4: Exactly the same scenario as in fig. 3 except that the simulator was modified to support vehicles coordinating lane change with the vehicles on the main lane. (Notice the absence of congestion.)

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, 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

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Sentient Future Competion: Highly Commended Entries

Sentient Future Competition: Ambient Intelligence by Collaborative Eye Tracking

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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 embedded in our homes, offices and transportation systems. They will form an intelligent ubiquitous 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 precisely planned, it follows responding 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 bored, 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 different devices that can be dynamically networked together 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 is carefully designed by hand. Most sensor network applications are implemented as complex, low level programs that dictate 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 designed to include the new rich media presentation hardware. A multiple thin and bright monitor screens, along with interactive whiteboards will be used for smart remote conferencing systems. Smart spaces and interactive furniture design projects have shown systems where tables, floors, walls, chairs and ceilings. Exploiting the capabilities of all these technologies is complex. For example, faced with several monitors, all but a few participants 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 coordination of media-rich evolvement strategies in meetings requires a need to support a way to navigate a meeting among meeting participants with appropriate tools for managing these monitors. Research in areas such as context awareness in pervasive computing, interactive furniture, and mobile devices is increasingly popular. 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 members 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 are the receivers, once your devices, or other device receive information, the information of your location is potentially available in public. The design of the system will need to consider multi-disciplinary efforts among 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 sound of the video streams either by increasing the volume of the stream, or scaling the volumes by temporal distance from the stream. Thus, the less recently selected streams are less chances to be increased volume of the sound. 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.

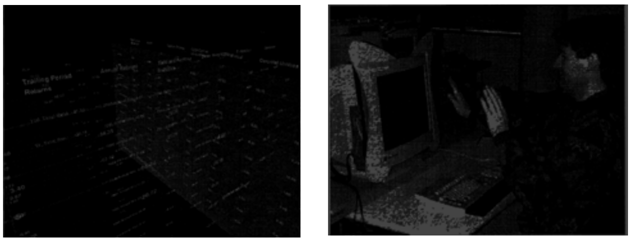

Figure 1: 3D Internet navigation by hand gesture (from [17])

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 coordination of conversational turn taking. In multi-party conversations, when the current speaker finishes his/her talks, it is not clear who will be the next speaker. According to statistics, the previous speaker's eye direction decides who will be the next speaker in many cases, where the next speaker will be the conversation partner in many cases. Thus, their eye contact with each other plays an important 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.

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

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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.

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.

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 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

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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. ACKNOWLEDGMENTS

Many special thanks to Ms. 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.

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Sentient Future Competition: Father in Womb

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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.

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.

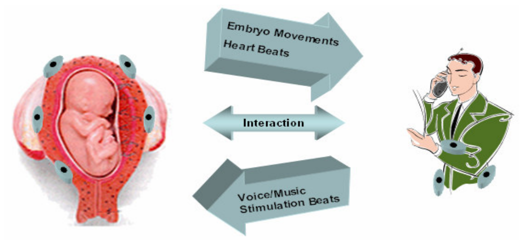

Figure 1- Sensor interaction between the father and the embryo

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

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Sentient Future Competition: LocuSent – large scale locust control system

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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.

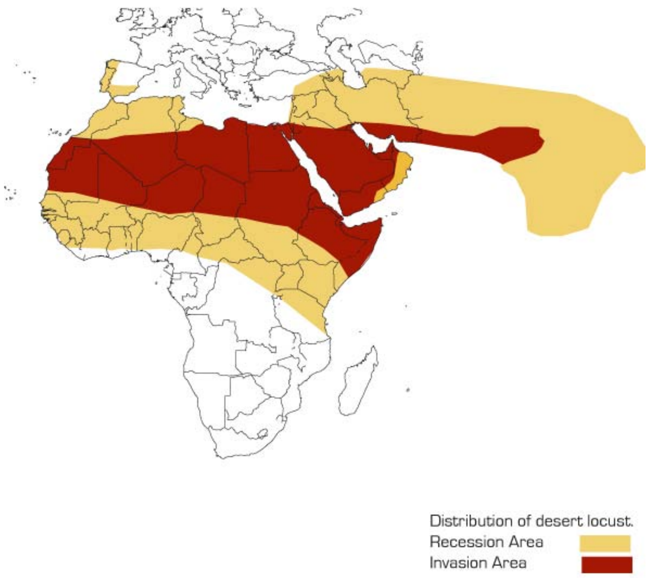
1. INTRODUCTION
Locust is the name given to the swarming phase of short-horned grasshoppers of the family Acrididae. The origins and apparent extinction of certain species of locust—some of which reach 15 cm in length—are unclear. There are species that can breed rapidly under suitable conditions and 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

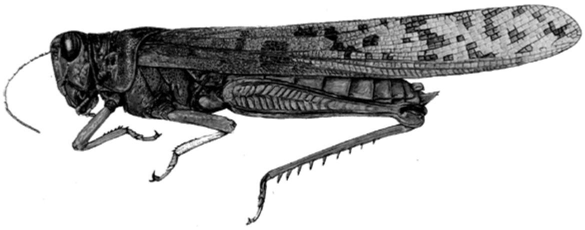
Monitoring locust populations during recession periods to anticipate the onset of gregarious behavior and to locate locust bands and swarms for control operations during outbreaks and plagues is a difficult task that has become increasingly technologically sophisticated. Model-generated forecasts of 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.

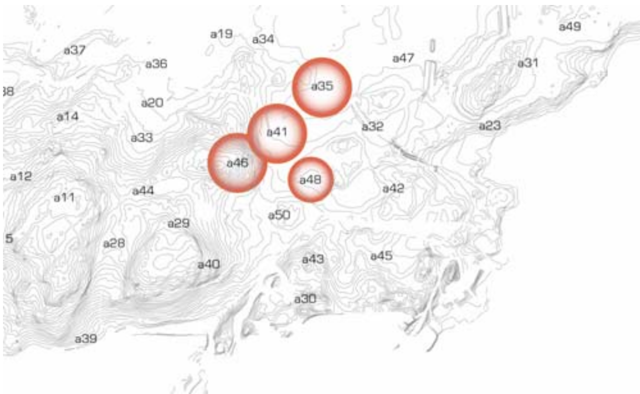
3.1 Detection by sound

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.

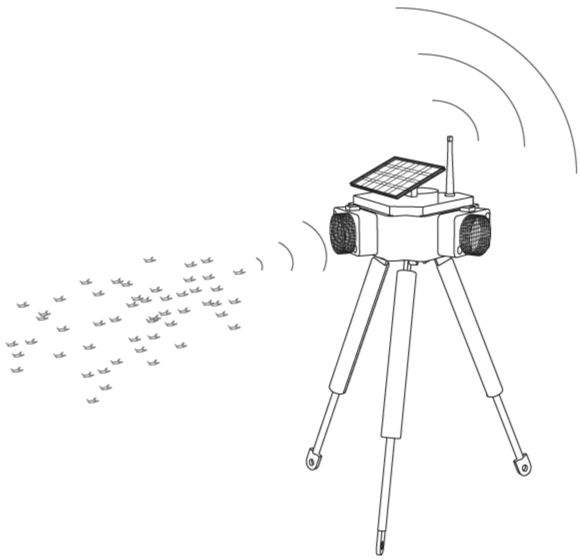


4. LOCUSENT

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.



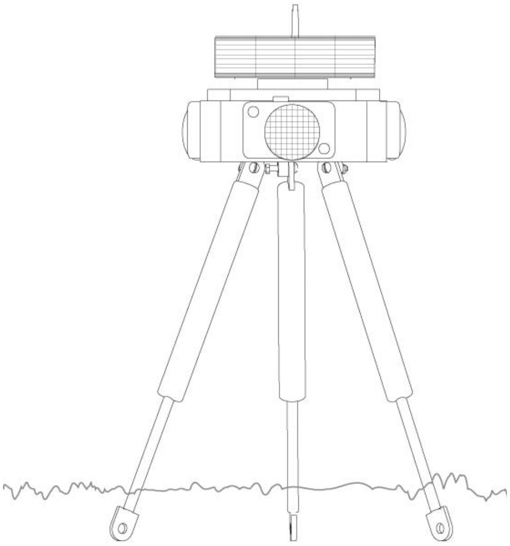
The desert locust is a difficult pest to control, and control measures are made more difficult by the large and often remote areas (16-30 million sq. km) where locusts can be found. Undeveloped basic infrastructure in some affected countries, limited resources for locust monitoring and control and political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

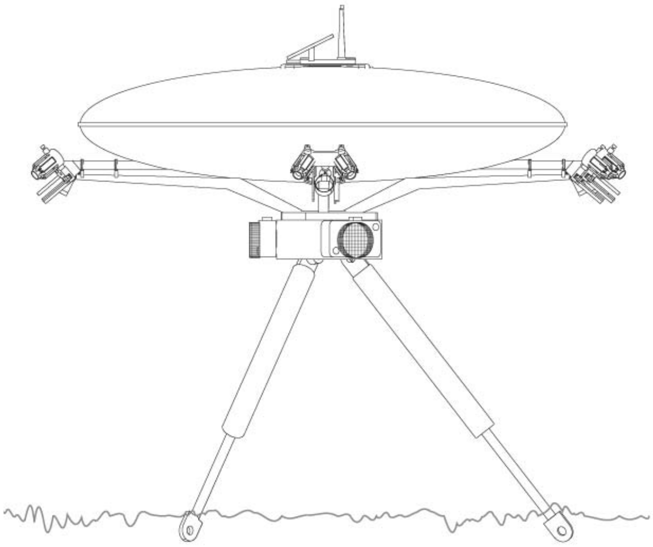


LocuSent monitor unit

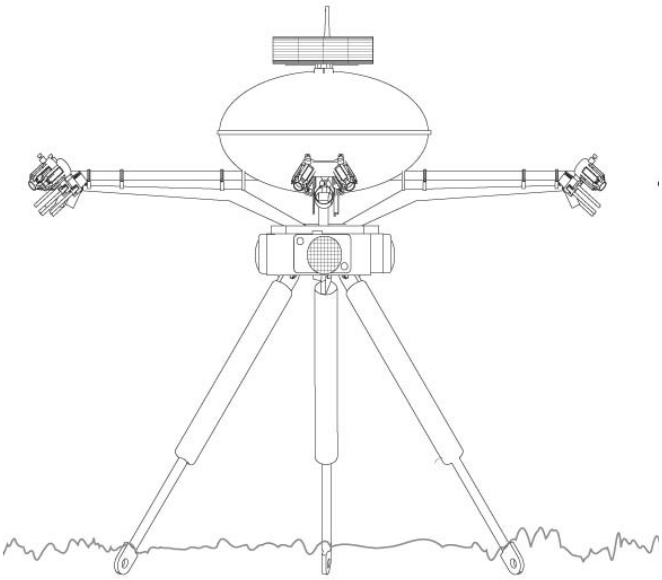
4.2 Biologic control

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: PerSens - Personality Sensors

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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.

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.

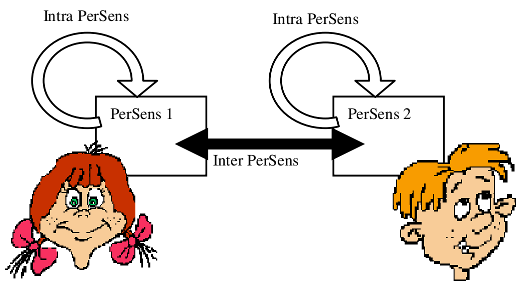
3. THE PerSens SYSTEM

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.

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Sentient Future Competition: Sentient Guardian Angel

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ABSTRACT
This proposal emphasizes the use of wireless sensor networks to omit dangerous traffic situations for a variety of participants in road traffic: pedestrians (elderly, disabled or simply careless people and children), cyclists or even 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. In our example we describe a pedestrian-car-interaction. However, the approach is applicable to all possible participants of road traffic.

1. 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 and an increased average age of population. Although today's vehicles are equipped with an increasing number of sensors, making life for drivers and passengers easier and safer there are no systems assisting pedestrians or cyclists. Examples for driver assistance systems are e.g. DaimlerChrysler's Distronic, a radar based distance control [2] and DaimlerChrysler´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" features.

2. VISION
The sensor system is supposed to prevent dangerous traffic situations in everyday life. Imagine a handicapped or careless person intending to cross a street. Such a 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 or careless pedestrian intends to cross the street. As a car is approaching he does not recognize the vehicle (Figure 1 However, the Sentient Guardian Angel builds an ad-hoc network exchanging information. The system evaluates the information and recognizes the approaching car (Figure 2).).

Furthermore, the car driver might not realize the pedestrian either, e.g. due to bad weather. The Sentient Guardian Angel recognizes the pedestrian and sends warnings to the driver. This enables the driver to react to the "abruptly" emerging person (Figure 3).

Thus, the system is able to guard in several ways:

(1) The pedestrian could be warned by the system, e.g. by causing

Figure 2: Sentient Guardian Angel alerting the pedestrian.

Figure 3: Sentient Guardian Angel alerting the driver.

vibration on the concerned side of the persons body or causing noise or other warnings.

(2) The pedestrian draws attention due to actors. The person is illuminated or the clothes are separating colored light

(3) The vehicle driver is warned by the system, either by signing flashes next to the car's dashboard or causing noise or other warnings.

(4) Finally the vehicle warns the pedestrian by flashing up the headlights of the car or using the car's horn.

3. TECHNICAL ARCHITECTURE

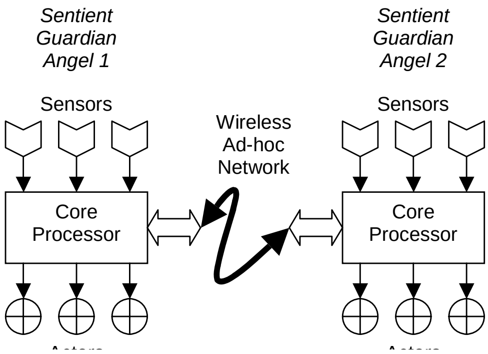

Figure 4: Basic architecture of the system

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 aim at highly miniaturized and autonomously acting systems (hardware, platforms) using wireless communication, e.g. µ-OS such as TinyOS or ContikiOS [5] or e-Grain [6]. Therefore the dimensions of the necessary components for the Sentient Guardian Angel are expected to be very small-sized.

3.1 Components of the System

3.1.1 Sensors

Sensors are needed for two main reasons.

Firstly, to detect the personal behavior in a certain traffic situation, which is characterized by a "motion vector". Therefore location (position) and orientation (compass) as well as velocity and acceleration sensors are needed. Alternatively precise location sensors could be of interest.

Secondly, sensors detecting the presence of other traffic components are required. This could be stationary equipment like traffic signs or traffic control e.g. traffic lights or dynamical factors like other traffic participants. Basically, there are two ways of detection: Local detection by noise pattern sensors, video pattern sensors, or ultrasonic sensors and intercommunication sensors by active near and medium field communication using active wireless technologies like

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

3.1.2 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 an appropriate 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

It's easy to be seen that there are two possible ways of indication, i.e. either to warn the endangered person itself or to warn others.

In addition, augmented reality technologies can be used for visualization 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.

3.1.3 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 built as soon as a minimum of two potential entities approach each other. Multiple 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 standardization.

3.1.4 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 built of a modular sensor network itself. Thus, "Active Jackets" could be designed more easily.

3.2 System Operation

As soon as an ad-hoc network connection is established, there will be an exchange of 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 action is required.

The characteristic set has to be exchanged only once between involved parties. It is quite important as children, elderly people or disabled people show quite a specific behavior 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 intending to cross the road. The local decision finding, implying several steps like "indication", "warning" and "advice" will be supported adequately.

The power supply of an "Active Jacket" could be realized by distributed generators using

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

4. APPROACH

The first step to enable the Sentient Guardian Angel is the development of sensor systems for pedestrians, cyclists and for motorists, respectively their vehicles. 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 a potentially dangerous situation.

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

As first step we propose 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 to help a vehicle driver to automatically react in dangerous situations.

Beyond personal guarding, the Sentient Guardian Angel infrastructure might contribute to telematics and navigation appliances.

5. ACKNOWLEDGMENTS

Our thanks to T-Systems Enterprise Services GmbH, for providing the creative atmosphere to deploy innovative ideas.

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