

MIMOSA

Microsystems platform for Mobile Services and Applications

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1 Introduction

The goal of MIMOSA is to make Ambient Intelligence a reality. MIMOSA achieves this by developing a personal mobile-device centric open technology platform to Ambient Intelligence. Microsystem technology is the key enabling technology for realising the MIMOSA platform due to its low-cost, low power consumption, and small size. The project will identify and develop generic microsystem building blocks for Ambient Intelligence. These blocks provide the required functionality for the local connectivity, context sensing, intuitive user interface, energy autonomy, and microsystem integration technology. The building blocks will first be utilised in four specific application areas: sports, fitness, health care and housing. For each application area, the project will implement a demonstrator during the first 30 project months. Later on, after the first 30 months of the project, the building blocks will be utilised also in more generic applications.

The aim of MIMOSA work package 1 (WP1) is to ensure that the development of the MIMOSA core technology is based on the needs of the users, and that the resulting technologies will be easy-to-use, useful and acceptable from the end user's point of view, as well as applicable from the application developers point of view. WP1 will take care that the MIMOSA project defines and maintains a common vision of the future, in the form of usage scenarios. These scenarios are used as the basis for user and application requirements for MIMOSA technology and architecture. Throughout the project, WP1 aims at illustrating the technical solutions to the users, evaluating the solutions with the users and refining the usage scenarios as well as user requirements based on the results.

This document introduces updated MIMOSA scenarios that are based on the initial MIMOSA scenarios (*D1.1 MIMOSA Initial Usage Scenarios*) and that have been evaluated for credibility or feasibility by users and project partners in three workshops (?). In addition, feedback and insight from the user evaluation of common users as well as experts of the Proof-of-Concepts is utilized in updating the scenarios. So the scenarios represent user need driven vision as well as technology push based vision of the partners of how MIMOSA technology could look and feel in everyday life.

The rest of the document is structured in the following way: Chapter 2 first introduces the main vision of the MIMOSA project - the MIMOSA approach to ambient intelligence. Chapter 3 describes the process and rationale behind updating the initial scenarios to the current ones. Chapter 4 presents the updated MIMOSA main scenarios; first general everyday scenarios and then scenarios for each of the selected application domains: sports, fitness, health care and housing. Chapter 5 describes scenarios and scenario-based design in general. Chapter 6 presents a State-of-the-Art overview of ambient intelligence research. We present and analyse ambient intelligence research and visions of key organisations and projects in the field, as well as that presented in recent journals and conferences.

2 MIMOSA vision

Ambient intelligence (Aml) will evolve into a new high-volume, fragmented market. The service value network for Aml contains several players. Aml becomes reality after a careful and a widely accepted definition of several open interfaces in hardware, software, protocols and user interface paradigms. These facts are recognised and fully taken into account in the MIMOSA vision of Aml. In this vision, personal mobile devices act as the principal gateway to ambient intelligence. Mobile devices provide trusted intelligent user interface and a wireless gateway to sensors, networks of sensors, local networks and the Internet.

The technology platform for Aml consists of the present telecommunication technology platform augmented with the following new key building blocks: wireless sensors exploiting the RFID technology at several ISM bands, highly integrated readers/writers for RFID tags and sensors, low-power MEMS-based RF components and modules, low-power short-range radios, advanced integration technology, and novel MEMS sensors for context sensitivity and intuitive, user-friendly interfaces.

In MIMOSA vision, the user feels and really is in control of Ambient Intelligence. Context-awareness and intuitive user interfaces are crucial for usability. Ambient intelligence applications help people in their everyday life: the applications are useful, usable, reliable, and ethical issues have been taken into account in the design.

3 Updating MIMOSA scenarios

3.1 Evaluation of the initial scenarios

The initial scenarios were produced with the contribution of all MIMOSA partners, technology and application developers. Based on a preliminary task, preliminary MIMOSA scenarios were collected by e-mail. These scenarios were then analysed and further developed as well as new scenarios created in a MIMOSA scenario workshop. The scenarios were later analysed to identify usage and application requirements, which lead to some refinements in the scenarios. The initial scenarios are published in the deliverable “*D1.1 MIMOSA Initial Usage Scenarios*”. The initial scenarios were evaluated by potential user groups (focus groups) and by MIMOSA partners.

3.1.1 Focus group evaluation

The initial scenarios were evaluated by potential user groups, which consist of two kinds of users, possible end users of the planned scenarios, and application field experts, such as doctors, nurses, professional athletes and trainers. In some groups (e.g. sports) we also had designers of current and future applications. The scenarios were given to the participants before the group discussion session, so that they could get acquainted with them.

The main evaluation method was focus groups, which refers to structured group interviews. Focus groups are widely used as a user study method in early product

development phases. The method inexpensively and quickly reveals potential user group's desires, needs, experiences, motivations and values. In group discussions several interviewees (around 4 to 8) are participating to the interview situation. Two to three evaluators participate in the interview: one as a moderator (interviewing and going through the material with the participants) and the other(s) as observer(s) taking notes. The discussions are audio or video recorded so that the discussion can be thoroughly analysed afterwards. The groups can be composed either of one homogeneous target group (e.g. elderly skiers) or a discussion group may consist of different kinds of end users and experts, like elderly people, single parents, youngsters and a doctors.

In the evaluations, the group discussions proceeded according to the following procedure. The scenarios to be evaluated were posted to the participants two weeks before the discussions. The participants were instructed to become acquainted with the scenarios before coming to the group discussion. The actual discussion situation proceeded in three phases. First, the participants were shown the scenarios one by one. Scenarios were pictured by photographs or drawings of usage contexts. In addition we had some examples of the outlook of the user interfaces for some usage situations. The moderator verbally explained the main aspects of each scenario. The participants discussed of each individual scenario in a freeform manner and also guided by some scenario-specific questions presented by the moderator. Second, after showing all the scenarios, the group discussed all scenarios in general.

Third, the participants were asked to fill a questionnaire form consisting of six statements on each scenario. The statements considered the credibility, ethicality, pleasurability, usefulness, usability, and adoptability of the service described in a scenario. The participants individually evaluated the statements on a five-grade Likert scale, according to how well the participant agreed with each statement considering the particular scenario. Altogether, the group discussion procedure took ca. two hours per group.

In the analysis of the statement evaluations, the degree of agreement of each statement was averaged over participants for each scenario. The agreement measures were then converted to a -50/50 scale, in which values close to -50 indicate strong disagreement and values close to 50 indicate strong agreement. The values close to zero indicate uncertainty of the value of a scenario. In addition, the statement measures were averaged over all statements for each scenario to obtain a single measure of "goodness" of a scenario, according to which the scenarios were ranked.

The French partners used the CAUTIC method for concept evaluations with potential end-users. The CAUTIC method is based on value proposals that are generated from scenarios. To some extent, the method gives a different kind of perspective to the scenarios. The CAUTIC method explores the reactions of users confronted with change in general, and the current innovation in particular. Starting with the novel concepts, the method evaluates the degree of potential adoption by a panel of carefully chosen target users. (Lelah et al. 2003)

3.1.2 Partner evaluation

The MIMOSA scenario evaluation was conducted with an internet evaluation form. It was agreed that at least one person from each MIMOSA partner organisation should fill in the form. There was no upper limit to the number of respondents per organisation. The form was available on-line for about two months (early July to early September 2004). The web form included both general ranking of the scenarios regarding how well they corresponded to the goals of MIMOSA project and detailed assessment of each individual scenario.

The respondents were asked to rate how good or bad the scenarios are in illustrating the goals of the MIMOSA project. They were also asked to assess the time scale within which they thought that the described technological solutions could be implemented. The detailed scenario evaluation included six Likert-scale statements similar to the user evaluations. In addition, the respondents could write comments about the scenario to a free text field.

3.1.3 Evaluation results

Health care is a promising application field. With suitable sensors, the users can be provided with systems that monitor their condition continuously, and report and alert with the user's personal mobile device. This is useful especially for people with chronic diseases. The interviewees innovated several kinds of sensors that might be useful. Self-care systems are easy to deploy, as they do not require infrastructures around. Self-care systems can collect data that the patient takes to his/her doctor the next time (s)he visits the doctor. These systems will presumably indicate no needs to change current work routines of health care professionals. If the systems include continuous monitoring or on-call duty by health care professionals, it should be studied in details how these systems will fit to the work routines of the professionals and related organisations, as well as existing information and communication systems.

With housing systems the main challenge is co-operation with existing house information systems. Also, the users will not be carrying their mobile phones with them at home, so the mobile phone centric system has to be based on the mobile phone connecting to the existing house network. Many operations are possible even if the user does not carry the device with him/her. An important function of the mobile device is to transfer information from the outside world to home and vice versa.

With both fitness and sports applications, extreme ease of use is critical. The system setup before the exercise must be simple enough so that the user has time and motivation to do it and does not forget anything. Context monitoring can be used to identify the need to start an application or to change application mode.

Key requirement regarding the MIMOSA architecture is the need to use the same personal mobile device for several different purposes such as health monitoring, sports assistant and fitness control, both parallel and by turns. Also, the user should have the possibility to use different devices in turns for the same tasks and be able to synchronise them easily.

As the evaluations were based on written and illustrated scenarios, the users could only limitedly assess how the sensors and UI components would look and feel. Tags

were included in many scenarios and the users based their conception of their look and feel to familiar concepts such as bar codes or IR controllers. Key issues are marking the tags in a consistent way so that the user can see where there are tags. The appearance of the tag should also indicate the functions that are included in it. In a similar way, tag readers in the environment should be marked in a consistent way. The reading should take place easily, without the user having to wave objects to read back and forth in front of the reader. More feedback to user interaction with tags will be got from user evaluations with the physical browsing proof of concept by VTT.

Smart plaster was easy to conceptualise and that is why the interviewees could point out several practical problems in using the plasters such as allergy, infections and moisture-impenetrability. Medical dosage via the plaster was assumed to introduce practical, judicial and ethical problems.

Monitoring sports performance by motion monitoring was expected to be quite complicated because so many movements should be measured in parallel. These kinds of applications were felt to be useful especially to support trainer-trainee relationships.

User interface technologies such as audio user interface, micro monitor and gesture-based user interfaces were felt useful in some applications but they did not raise many comments. These user interface techniques may have their most potential application field in everyday applications rather than in the four MIMOSA application fields. To get user feedback to these technologies we will need user evaluations with proof of concept prototypes. By actually using the proof of concepts the users will be able to assess the look and feel of those techniques.

The results of the evaluations indicate that context-awareness has good use in identifying the context to activate relevant application or to change the mode of an already active application. This would be especially important in sports and fitness to save the user from user interface operations before and in the middle of his/her exercises.

3.2 Evaluation of the Proof-of-Concepts

3.2.1 User evaluation

Four Proof-of-Concepts (PoC) have been evaluated: Physical Browsing by VTT, Housing by Legrand (evaluated by VTT), Fitness by Nokia (evaluated also by VTT), and Intelligent Medicament Detection by Cardiplus.

Physical Browsing is a new interaction paradigm for Ambient Intelligence (Aml), in which the user can access information or services about an object by physically selecting the object itself with a mobile phone. The Housing Proof-of-Concept demonstrates a home access system, which is controlled and monitored by a mobile phone. The Fitness Proof-of-Concept demonstrates a system for collecting and analysing personal fitness and health data in a continuous, long-term manner and that can be implemented in a mobile phone in the future. The Intelligent Medicament Detection is an example application of mobile phone based Aml services for health care and medication.

The evaluations were carried in spring and summer 2005 as interviews and experiments with altogether 47 non-expert test users. In addition, six health and fitness experts were interviewed for the Fitness Proof-of-Concept.

3.2.2 Evaluation results

The **Physical Browsing** Proof-of-Concept introduced the users with a new user interface paradigm where the user can interact with different physical objects in the environment as well as the environment itself by touching and pointing the object in question. This user interface paradigm turned out to be intuitive to the users, it was easy to learn and easy to use. Touching was assessed somewhat easier to use than pointing for the users. However, the users are reluctant to make any extra effort – they don't want to take extra steps to move closer to the tag to touch it if the tag is not within arm's reach. Some objects, such as dome lamps are not reachable for touching. Therefore, pointing is an important complementary interaction method, in addition to touching.

The minimum distance at which pointing was preferred instead of touching was measured to be approximately 1,2 m. When moving, it appears that the users prefer pointing even if they pass the tag closer (ca. 1 m). This should be evaluated in a more profound manner with a fully functioning pointing system and in ecologically valid situations, as there are a number of factors that might affect whether a user chooses touching or pointing a tag in a specific situation. However, if pointing is to be implemented as an interaction method within the MIMOSA technology platform, it should be noted that the user's intuitive pointing distance appears to be clearly more than 1 m and there is no use for pointing technology if it works only at distances shorter than that. The distance measures of the Housing evaluation support this conclusion. In the evaluation, users approached to a door by walking, and the distance at which they intuitively pointed as to unlock the door was 2-3 m in average.

In the evaluations it became clear that in some situations touching a tag can directly trigger an action but in other situations user confirmation is needed. The need for confirmation depends both on user preferences and the task at hand. Touching was perceived to be more reliable than pointing in this regard. Confirmation may be related to the reading of the tag as in our evaluations but it can also be implemented within the application in question. As users get surrounded by increasing amount of tags, it may no more be possible to keep the phone in tag read mode all the time – not even with the touching method. The user needs easy ways to activate and switch off the tag reader.

With small physical objects some users decided to pick up the tagged object and bring it close to the phone for reading. This is an interesting enhancement to the physical browsing paradigm and is worth further studies.

The Physical Browsing Proof-of-Concept was evaluated in usage scenarios that took place at home and included only a handful of tags. As tags are getting more common, it can be expected that several browsable tags are around the user in many situations, not only home but in public places, in traffic, at work and so on. This brings in new challenges for the user interface paradigm and will require further user

evaluations. For instance in public places privacy becomes important, the user may not want to show to others where (s)he is pointing at. On the other hand, the users may wear or carry objects with tags and for privacy they would not want others to be able to read those tags from a distance.

In the **Housing** Proof-of-Concept evaluation, an Ambient Intelligence access control system was studied. In general, the users accepted the idea of the control access system used by a mobile phone. Especially the idea of a temporary door-unlocking license in the mobile phone of occasional visitors such as a maintenance man was appreciated.

The unlocking should be as effortless as possible. The identification of the person approaching the door, unlocking (and in some cases also opening) the door should occur automatically. However, in the Physical Browsing evaluation, the users required confirmation for unlocking the door with a mobile phone. The explanation for this contradiction may be that in this evaluation the users imagined themselves as being inside in the house and unlocking the door for somebody coming in. This was experienced to be more critical to the security of the person. Also, the feedback of the unlocking might not be obvious, for instance if the unlocker was in another room not close to the door.

The security of the system is an important issue for the users. Electric locks are felt reliable and more flexible than mechanical lock systems, but the security of internet-based solutions is doubted. Problems raised in the issue of the mobile key were whether the unlocking would work even if the battery was dead, and what if the mobile is lost.

The **Fitness** Proof-of-Concept evaluation showed that there is much potential in the domain of health and fitness measurements. People are deeply interest in their health, although different potential users value different kind of measures and would use them for different purposes. Thus there seems to be room for MIMOSA type platform that can be flexibly used with different sensors and applications.

However, the evaluations also revealed threats in implementing welfare applications. In this application field, reliability of the measurements is extremely important and it should be guaranteed. The users often had problems in interpreting the measurement data. It is not enough to present measured values as such but the numbers should be analysed and perhaps synthesised with other measurements as well as properly visualised to provide the users with understandable information about their well-being and health. Sometimes, an analysis made by a computer is not felt reliable, but a human interpretation by a professional is needed. Feedback on dehydration and stress was felt useful by the users but the medical professionals emphasised that dehydration and stress cannot currently be reliably analysed. With stress-related measurements MIMOSA could co-operate with FP6 project SENSATION that is specialised in analysing stress in occupational health care.

Long-term measuring of health-related parameters was particularly promoted by the health experts. This kind of data would support a person's medical diagnosis and rehabilitation in an effective way. In addition, the data would be useful for research

purposes. Long-term monitoring cannot be based on the user carrying a mobile phone with him/her all the time. The users were reluctant to carrying the phone even in short-term exercises such as jogging. Current welfare sensors and devices are also often inconvenient to wear such as the heart rate measurement unit (belt). We should increasingly consider solutions where an easy-to-wear sensor unit collects measurements and when the personal mobile phone is near, transfers the collected data to the phone. The wristop computer is more suitable for sports and fitness use but it has limited capacity and thus also requires unloading every now and then.

Having fun and being a part of a social network were considered important in connection to systems that aim to motivate users for permanent changes in they ways of living. Getting started is especially difficult, and the users would appreciate solutions that could motivate the user by showing the small changes in the beginning. The feedback to the user should be given in concrete form, such as the butter packets with which the Weight Watchers describe the lost weight. The user should also get the feedback in time so that (s)he can react and take corrective actions, for instance drink water before the dehydration level becomes too low or slow down running before the lactate level becomes too high.

The **Intelligent Medicament Detection** Proof-of-Concept was found to be a valuable example of Ambient Intelligence for helping people in the medication issues. The Medicament Proof-of-Concept was designed to easily provide the user with different useful information of medicines in demand and even instructions, such as warning the user for a harmful medicine. The application should not, however, be too predictive. The feature of an automatic call for medical guidance if the system detected a potentially harmful medicine was not accepted.

The privacy issues were of concern also in the case of Intelligent Medicament Detection. Personal clinical and medication history are private information. If they are stored in the mobile phone, one should be able to control the sharing of the information as well as protect the mobile from viruses or other possible ways of misuse, whether it is deliberate or non-deliberate.

3.3 Workshop I, Kiviranta, Finland

Partners from VTT and Nokia were present in the workshop in Kiviranta. Scenarios in the domains of Housing, Health care, Fitness, and Everyday were analysed. The comments and suggestions considering the initial scenarios are presented below.

3.3.1 Housing

Housing was seen as a problematic field for MIMOSA. Users feel that there is no need for excess technology at home. Home entertainment and household devices are an exception but outside MIMOSA's focus. Another exception is safety and security, but the mobile phone is not a technology reliable enough for safety critical systems. In addition, people do not want to carry a mobile phone with them at home. Support for independent living is accepted, but a wristop device can be more applicable device for this purpose, than a mobile phone.

New ideas were presented considering everyday organisation in a family, who takes children to hobbies, who needs the car etc. In addition enhancements in the entry system, such as who were at home like friends for children, and who emptied the fridge. These kinds of scenarios require special attention to privacy issues.

The washing machine scenario as such was rejected as unworkable and not MIMOSA. Tags could however contain the washing instructions of clothes, as a tag would be more convenient than a piece of cloth in the neck. Another function of tags in clothes could be measuring the body temperature – e.g., of children when they are at nursery. A question is whether tags are durable enough for machine wash.

Motion detection was pointed out to be already existing in house automation. The MIMOSA style would be pointing, saying, clapping hands to put lights on.

Identifying the person in shower was thought to be technically difficult and unnecessary as people want different water temperatures at different times. Rather there would be a need for a set of personal defaults. The scenario was thought to be out of the focus of MIMOSA.

The automatically updating shopping list in the kitchen included several practical problems. All cast-off fridge items are not always needed, and often there is a need to buy items before the previous package is totally empty. The usefulness of excess automation was doubted. A better solution would be to keep the user in control. For instance, the user could show an empty package to the shopping list, which would add the item into the list. However, automatic identification of outdated or bad-gone groceries by the fridge might work in practice. Also, getting the shopping list to the mobile phone would be useful. New useful ideas were being able to contact the fridge remotely by the mobile phone for checking the shopping list & post-it notes on the fridge door when in the shop.

Regarding to safety and security at home, it was pointed out that several commercial solutions for monitoring human vital functions and recognising falling are already available. MIMOSA could provide simple solutions for safety – for instance, monitoring daily activities and issues such as water consumption would allow the system to alert if there was an exception in these. One should realise that the individual differences considering safety and security are considerable. The solutions are especially important to the elderly, who have not been included in the user evaluations so far.

Safety and security are sensitive issues in which reliability is important. It was questioned whether tag and mobile phone based systems are reliable enough. One solution would be use these as parallel to other solutions. As a mobile phone based solution is cheap, it may also work as stand-alone if there was no specific and serious reason for continuous monitoring (such as a chronic disease).

The user may not want to carry a mobile phone all the time at home, but the phone could be used as a terminal for different things such as home automation, a tag-based house log, damage (smoke or water leakage) detection system, and thief alarm system. These would be especially useful for a travelling user.

In home systems, a small sensor size is not necessary, but low power consumption is required. The system should be easy to install and introduce to the user. Tag-based solutions are easy and cheap also to update.

The mobile phone as a universal terminal device for controlling all kind of home appliances is an often presented scenario. A problem is that there already is other and easier terminal devices available at home (e.g., TV). It may not be clear whether users want separate terminal devices for different purposes or an all-integrating device. In addition, the mobile user interface is not suitable for all kinds of information. Interesting is, whether there could be some added value to have a personal remote controller (phone) for each TV watcher, for instance. Another problem is that the tag reading distance of the mobile phone is quite short and thus sets limits to the use. Another option is that the mobile phone would redirect information between different devices or appliances. For instance, the washing machine could communicate the ending of a washing program to the TV and thus to the user. However, this scenario is out of MIMOSA.

The weather forecast scenario was rejected as incredible. The remote reading of outdoor thermometer might be useful – especially the weather history (to check how cold was it last night, for instance). The diaper scenario was also commented to be neither acceptable nor useful. Using the mobile phone to monitor the well-being of children and elderly was thought to be relevant.

The lost items scenario was considered useful, but commercial solutions already exist for this purpose. The scenario might be improved if sound feedback (even quiet) would be possible. A tag attached into an item could also store the history of use by collecting all sensor measurements of the lifetime of the item. This idea could be implemented as a house log book.

The access control scenario with a cleaning lady was commented to be incredible by the users in the scenario evaluation, and was thus changed to a story of a maintenance man. As such, the access control scenario was accepted. Positive aspects in the scenario were storing of the door status data and remote access to it. The system could store information of who has tried to access the house, and facilitate receiving deliveries and maintenance by letting only the appropriate persons to access. Also, the mobile phone used as a key might work. Security of the system should be considered carefully. For instance, corresponding car systems have already been cracked by capturing the lock signal by thieves.

3.3.2 Health care

Health care is an important field of Ambient Intelligence applications. It is also a difficult field because of the significance and sensitiveness of personal health information. Requirements for health care applications are set not only by the user but also by the society and the family of the user.

Health monitoring systems were thought useful in their versatility. The system could collect health-related history of the user for the next visit to the doctor. Patients could be monitored after sending them home from the hospital. Medicine dosage in the

blood could be monitored to check the regular dosage as well as to remind to take the medicine.

An Aml health care system could also facilitate prevention of diseases and increase well-being by monitoring sleeping, exercising, nutrition, stress, and taking of drugs such as tobacco or alcohol. These kinds of applications could support self-control and so facilitate keeping healthy. For exercising, an Aml system could facilitate monitoring and recognising exercise type, efficiency and amount of it.

An important function of Aml would be long-term monitoring to identify trends in different aspects of life (e.g., health) for both the user him/herself and for professionals. Long-term monitoring (even years) would require external databases and backups. Dealing with this kind patient data is an important challenge but not in MIMOSA's focus.

Several new applications for the smart plaster were presented. It was concluded that dosage does not work with insulin (dosage volume), and insulin level can currently be measured without needles, but blood sugar needs to be measured from blood. The idea of mobile access from the smart plaster is good.

Medical history on phone was thought to be important but not MIMOSA. Prescriptions in the phone would be useful when travelling especially for children's medicine (dosage according to the weight). However, the patient cannot be responsible for selecting the medicine. It was commented that this is not a key MIMOSA application for health care.

For heart problems, the health care personnel would make use of long term monitoring of life style (activity, nutrition, ..), information that would help in making diagnosis. This kind of life style measurements are also accepted by users for self care. Analysing and processing several measurements is needed to conclude about the status of the patient. Furthermore, solutions that increase motivation for rehabilitation are accepted. To support independent living at home, a remote controller with contextually adaptive user interface would be good.

3.3.3 Fitness

Fitness centre systems that are based on electronic client cards storing personal training programmes and communicate them to the fitness equipment already exist (for example, HUR, in Turku, Finland). The fitness equipment will however increasingly include personalised and intelligent features, and there might be added value of using a personal mobile phone in fitness. For instance, when visiting other centres, the same fitness and equipment set-up data could be used if it was in the mobile phone. Also, long-term monitoring would be possible. Motivation is increased by having a clear goal and being able to monitor progress with personal records and highlights as well as long term recordings. Privacy protection would of course be taken care of.

Adidas and Polar have developed a shirt with integrated heart rate measurement. It is interesting, that in the evaluations the users did not find the idea of a separate measurement shirt acceptable. It is however possible that in the future there will be

commercial fitness shirts routinely equipped with standardised sensors. These could be used, for instance, to prevent injuries when lifting weights.

There is motivation for weight watching data collection, as the interviewed Weight Watchers told. Tags could be included in the Weight Watcher diet book, for instance. As the precise energy consumption is hard to measure, overall activity level during the day would be useful feedback for weight watchers. A game type application could motivate to exercise and so give an added value. The user community, which appears to be important to weight watchers, should be included in the scenarios.

For fitness, measuring heart rate training zones would be useful, but requires an expert opinion. The lactate measuring was accepted, similar to micronutrients – however, the latter may not be possible. A "miniature stethoscope" and breathing sensor based on microphone could be nicer to wear than a heart rate belt. Measuring stretching was seen useful, but it is not sure would it be technically possible.

In general, the fitness scenarios should be simplified. It was commented that the community and fun are missing, and they could be added especially to the weight watching scenario, maybe in a game format. Long-term monitoring would be needed, as it takes years to learn a sport and to improve the physical condition.

3.3.4 Everyday

For everyday scenarios, it was suggested that context data from sensors would be nice to spice up photos and videos (some research is already going on with this). Another possibility was comparing trade descriptions according to the consumer profile, e.g., has this cloth been manufactured using child labour. There should be specific scenarios for the microprojector. It has not been realised that the projector allows not only a projected phone screen but a bigger view due to bigger (VGA) resolution (e.g. communicator is only ½ VGA). This would be useful for maps and other guidance for instance. A question is that can the device be hold stable while watching. This will require user evaluation. Again, game scenarios are needed to include multi-user applications and fun.

3.4 Workshop II, Crolles, France

In the Crolles workshop, partners from VTT, Nokia, Legrand, Cardiplus, Suunto, were present. Scenarios from the domains of Fitness, Housing, and Health care were analysed. The workshop participants identified and refined a primary demonstrator scenario, and another scenario that would complete the primary one. As one purpose of the workshop was to decrease the number of scenarios, other scenarios were left away. To facilitate the scenario analysis, the initial scenarios, user evaluation results, and results of the Kiviranta workshop were used as supporting material. In addition, following supporting questions were provided: Which issues are the main value proposals? Which issues work? Which issues are useless, not MIMOSA or having "noise"? The results of this workshop are presented as the updated MIMOSA scenarios (chapter 4).

3.5 Other material

4 MIMOSA scenarios

The following sub chapters describe how MIMOSA technology could look and feel in different everyday situations generally and specifically in the four MIMOSA applications fields: sports, fitness, health care and housing. The updated scenarios represent technology push approach that have been evaluated for credibility, acceptability and technical feasibility based on user evaluation results and feedback from technology and application developers.. Parts of these scenarios have been implemented as proof-of-concept technology demonstrators, based on existing technology. The proof-of-concepts have been evaluated by common users and relevant field experts as well. Towards the end of the project, parts of the scenarios will be implemented with the actual MIMOSA technology as MIMOSA demonstrators.

The scenarios describe several alternatives to utilise MIMOSA technology. The scenarios mix technical solutions that are available already today, solutions that will become possible with MIMOSA technology and also some "hype" elements - applications for which we do not currently know the technical solution. The scenarios also include elements that as such are not in the focus of MIMOSA project. This reminds that MIMOSA technology should not be developed only on its own; real life applications and services will need to co-operate with other, already existing or evolving technologies and solutions.

The scenarios represent MIMOSA vision of the user feeling and really being in control of Ambient Intelligence. In most cases, the user actuates the interaction with the ambient intelligence. If the environment is the actuator, rather than acting automatically, the ambient intelligence applications provide the user with justified suggestions that the user can approve or refuse. Automatic actions are based on profiles and personalisation and the user has the control to easily activate and deactivate them.

4.1 Everyday scenarios

The scenarios presented in this chapter illustrate how smart tags could be utilised in different everyday environments. We are using two concepts to act with tags: touching the tag and pointing towards the tag.

Compared to already existing RFID technology, the becoming MIMOSA technology creates longer reading distances and even smaller physical device size. Thus tags can be embedded in almost any everyday objects.

4.1.1 Movie poster

Johanna is at town and sees an interesting movie poster. Actually she has seen movie's trailer before, and she liked the soundtrack. Johanna points the soundtrack tag in the poster and downloads it to her phone. She sets the soundtrack as the ringing tone. After this she points another tag in the poster, which responds by sending an alarm of the movie's premier

to her mobile phone's calendar. Later on, at the premier day, Johanna's mobile phone will remind her of the movie.

4.1.2 Where did I park

Sven is driving to a shopping mall's car park. There are several floors in the garage, but he is not worried about finding back to his car, since he knows that the parking places are equipped with smart tags and his mobile phone has a tag reader. He parks his car and then he walks to the Point Me sign over the parking place, sets the phone to the "read tag" mode and then points the sign with his phone. The phone receives the parking place information (floor, parking line and place number) and now Sven can easily leave the garage to do some shopping. After the shopping, he arrives to the car park and picks up the parking place notification from his phone's tag inbox. He puts the phone next to car park's public UI appliance screen and drops the tag there. Now he knows where his car is - all he has to do is to follow the car park's signs.

4.1.3 At the bus stop

Kaisa is leaving from her piano lessons and is walking to the bus stop. She does not know when the next bus is coming, but she knows from the bus stop's number sign that the bus will stop here. She takes her mobile phone, sets it to the "read tag" mode and points the bus number on the bus shelter's wall. The interactive bus route map display on the wall of the bus stop now highlights the route of Kaisa's bus, shows current location and movement on the route, and gives an estimation of the waiting time. If Kaisa would not know the number of the bus line, she could alternatively point her destination on the info map at the bus stop and then get route guidance based on her identified current location and destination.

As there is still 15 minutes time, Kaisa adds an arrival alert to her mobile phone, which will inform her by a sound when the bus is two minutes from the bus stop. Then she leaves for a cup of coffee to the nearest café.

4.1.4 Shopping and navigation assistance for the weak-sighted

Jesse is going to the food store to get some supplements to the fridge. He knows the route to the shop well as well as to other common places nearby – he has learnt them by heart as he is blind from birth. His condition used to cause him problems in the shop as he could not read the labels in the food packages, so he needed an assisting person to do shopping with him. However, recently all packages have been tagged, and therefore Jesse is now able to use his mobile phone to read the tags and translate the information to speech. Jesse also wears an earphone so that he does not disturb the other customers in the shop.

The local food store has implemented a map system, which Jesse activates as he enters the store. The system tells him by speech what foods and other materials he has around, and advises how to navigate in the shop. A similar navigation system works in streets also, as the street signs, traffic signs, and other navigation signs are tagged. So Jesse is able to read their contents and position relative to his from a distance of 10 meters.

4.2 Sports scenarios

The updated version of the scenarios is based on the feedback get from user and expert evaluations and discussions with the application field owner, Suunto. The final update is made after the Proof-of-concept evaluations.

4.2.1 Golf with a friend

The context

Marie and Brigitte are going to first practise golf on a practice field and after that to play. Both of them have new kind of sports application for practising and playing.

The application

The golf club is equipped with an Inertial Measurement Unit (IMU), which is used to measure the speed and acceleration of the club in 3 dimensions. One gets information of the speed of the golf club's head during the swing, backswing, and downswing and from the interrelationship between these two. The measurement is transmitted to her wristop computer automatically with a short distance radio. Golf shoes have pressure sensors for measuring her balance changes during the swing. Also the shoes transmit their measurement automatically to the wristop computer. The wristop computer analyses the data. Based on the measurement data the application can suggest changes to the swing or to the posture of the player. This information is displayed on the device after each swing.

The rehearsal

The applications are activated by pressing one button. The different parts of the application (shoes and club) are connected now wirelessly to the wristop. Now Marie is ready to start. She swings the club and hits the ball. According to the results of her swing she leans too much forward. Marie takes few more rehearsals and she feels that she is now ready to start playing. Brigitte also makes some rehearsals. After the swing analysis Brigitte's swings are rather inconsistent. Marie, as a more experienced player, guides (according the analysis) Brigitte to find more consistent swinging technique and posture.

Game

After the rehearsal Marie and Brigitte are ready to start playing. All of their golf clubs are equipped with tags and sensors. Their wristop computers have a program that helps them to keep track of which golf clubs they have been using and which golf courses they have been playing at. During the game, the golf club sends the measurements from its buffer to the wristop computer. The wristop computer also reads the measurements from the shoes. While playing her own game, Marie can also follow her own and some of her friends game at the same green few days ago. She has been loading her friend's game information to her wristop in her home by Internet.



At home Marie can compare her, Brigitte's or Tiger Wood's performances at her Golf Program on PC. She notices from the graphical diagram that her performance has improved

lately. She can also share her own information via Internet and she can define the publicity of that information (public - defined group)

4.2.2 Running competition

Pierre is interested in long-distance running and he also participates regularly to competitions. Today Pierre takes part to the Stockholm Marathon. Pierre has a intelligent sporting system with him. By this system he can follow his performance during the competition.

There are RFID tagged waypoints installed all the way to the running track at a few hundred meters intervals. Every time a runner goes by the waypoint the runners wristop gets information how the runner is performing. The audience, co-competitors and e.g. coach can also follow up the positions and performance, even biometric information, with this new system.

Pierre decides that in this competition his objective speed should be 4, 15 minutes per one kilometre. Pierre sets his wristop computer to warn him if his speed is going to be too fast e.g. because of the take off of the other competitors. He puts his accessories on standby by touching them with his wristop computer. He puts on his running shoes, puts a wireless earplug miniature loudspeaker in his ear, smart plaster onto his arm and wears his microphone-equipped shirt and wristop computer. The application activates automatically when the competition starts.

Pierre's wristop computer starts monitoring his heart rate and breathing with the microphone on his chest. The sound of his breathing and heartbeat are analysed in real time in the wristop computer. When Pierre's breathing technique is not optimal, he hears from his earplug loudspeaker directions to breathe deeper and through his nose, for example. Pierre's heart rate monitor in the wristop computer also notices that he should run faster to get to the predetermined heart rate level and gives voice feedback to the Pierre's earplug.

Pierre has a smart plaster attached to his skin for measuring lactate level and to help him keep it low, which is suitable for a long time exercise and competition. The plaster is connected to an RFID tag for communication with his wristop computer. Wristop analyses the heart rate, the lactate level and training duration and suggests to Pierre that he drinks and takes glucose on suitable intervals.

After a few kilometres, Pierre's mobile terminal warns him (with the earplug) that his lactate level is increasing too rapidly corresponding that his heart rate is nearing the anaerobic level and he still has quite a few kilometres to go. He is told that he should slow down a bit to keep his pace suitable even though co-competitors are bypassing him.

In the last five kilometres however Pierre is bypassing the competitors that overhaul him ten kilometres ago. Pierre has now the fifth position. He takes a look how the competitors ahead of him are doing. He calculates that if he can keep his pace he could reach the third place because two other competitors are slowing clearly down and their lactate levels are extremely high.

Pierre finished third in the marathon! Steady speed, rightly modified to Pierre, was again successful strategy. After finishing, Pierre downloads speed data from his running shoes. The shoes have accelerometers, whose data is used to measure the running speed and the length of his step. The speed and step information is combined with the timestamps from the way point posts, heart rate and breathing frequency. He gets a graph, which includes this information and uploads it with the data later into his computer and the Internet for further analysis, comparisons and sharing with his trainer and friends.

4.2.3 Other possible sporting applications: Tennis and downhill skiing

In Tennis application there is overhead cameras at the tennis court. The cameras are activated automatically when players come to the court. The player can mark the balls or games he wants to save by pointing the tag installed in the wall. After the game player can transfer the selected data from the overhead camera to his/her own mobile phone.

In tennis and in downhill skiing one can utilise shoes, which have pressure sensors in the front and back area of them. With these shoes the performance posture is determined and suggestions for changing e.g. balance can be given.



One can have an inertial navigation unit in snowboard to get information of how high and long jumps have been.

The positioning of the persons (kids, friends) can be arranged also with RFID tag implemented clothes. When person passes through a reader-equipped gate to a lift, the resort's system records person's last location, alongside with a timestamp. This information is also used to provide the skiers with location-aware information and services. Not anyone can be tracked with this system, but rather the skiers may allow certain other skiers (predefined group) access their location information.

4.3 Fitness scenarios

4.3.1 Controlling weight

Ville has gained few extra kilograms of weight during the last couple of years. Now he wants to be aware of his activity and food intake in order to control his weight more easily. Ville decides to use the fitness monitor, which measures Ville's heart-rate, steps and also fat percentage. When Ville eats something, he chooses a matching meal from the fitness monitors' menu and stores the intake food data.

The device performs long-term monitoring for Ville and gives positive feedback when applicable. The device can distinguish whether Ville is walking or running, climbing the stairs and takes different situations into account when measuring the consumed energy.

The Fitness Monitor calculates the balance between intake and consumed energy in daily bases and shows the trend of progress with an easily readable graphical representation on the device's display.

4.3.2 Fitness game

A new fitness game is launched and Mikko is interested in taking part. There is a central server in the Internet that Mikko can use to register for the game. He chooses to register for 2 hours of movement game. A task is presented to him: "Find a brown bicycle". The point is to find the object, take a picture of it and send it to the game server. The game is played using the Fitness Monitor, which monitors the consumed energy). The first person who finds the wanted item and photographs it will get as many points as he consumed calories while performing the task. The person who comes second, gets only half of the points of consumed calories (but he/she of course could have used more time or calories in finding the target). and so on.

There is a possibility to compete with friends or the average trend in the internet for the selected time. Having more advanced sensors in the Fitness Monitor, the tasks can become more complex. Mikko decides to challenge his work colleagues to the game. It's not necessary for all the players to complete the tasks simultaneously, the game can also be turn based – you can play your turn when you have time.

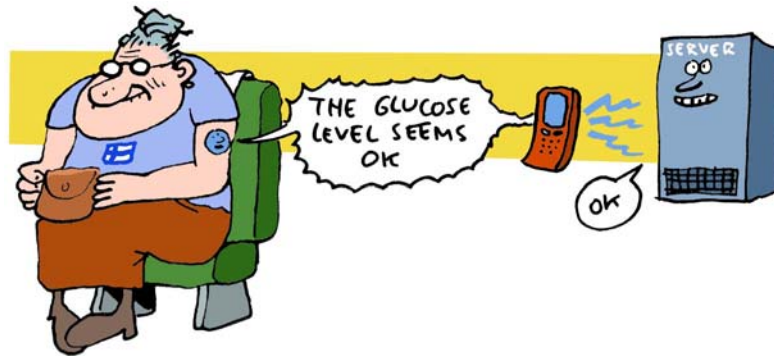
4.4 Health care scenarios

4.4.1 Travelling and taking care of diabetes

Ines is retired and travels a lot despite of her diabetes. For diabetic persons, it is vitally important to frequently monitor their blood sugar (glucose) level. If it is too low, it could lead to unconsciousness, or if it is too high, it could cause ketone poisoning of the blood.

At home, Ines uses a quick blood test to monitor her blood sugar level and injects insulin regularly. However, when travelling, she feels that diabetic-special smart plasters are handier because of irregular life during travel. The smart plaster can be worn for 24 hours at a time and it monitors glucose level of the blood as well as automatically adjusts the insulin dosage according to the user. The plaster is easy to use and wear. Negative in the smart plaster is its price.

A smart plaster analyses the glucose level of the blood sampled by the micro needles of the plaster. This information is sent via Bluetooth to a mobile phone. The mobile phone warns if the blood sugar level starts to be seriously offset. In addition, the information is sent to a server, which stores the data for later analysis. Based on the long-term information of the glucose level variation, the diabetic together with his/her supporting team can evaluate whether the treatment (insulin injections, diabetes pills, nutrition, workout, etc.) has been effective.



In a four-week travel to China, Ines notices that her insulin will be running out in a few days. Ines goes to the local pharmacy, in which all medicine labels are written in China only. The pharmacist does not speak English either. However, all the medicine packs are tagged so that their information can be read with a mobile phone from a server database. As there is no familiar-looking insulin pack in the pharmacy, Ines uses her mobile phone to recognise equivalent insulin. The hand-held device indicates appropriate insulin with a light signal and also checks compatibility of the medicine to other medicines Ines is using as well as allergies. In case of incompatibility, the hand-held device would alert Ines. When Ines buys the insulin, it is automatically checked to the medical history database (in the mobile phone and/or server?).

In case there would have not been all relevant information available in the medicine database, or if connection to the database would have been failed, the mobile phone would have suggested contacting Ines' family doctor or the local call centre for advice. The family doctor has access to Ines' medical history as agreed with Ines earlier, so the doctor is able to follow Ines' medical conditions on-line whenever needed.

4.4.2 Looking after Louis the toddler

Rosalita and Jorge have a 20-month old son Louis suffering from several allergies and an often repeating flu. The parents has put small, light-weight wearable sensors on Louis' skin that continuously measure his skin temperature and sweating. In Louis' clothes, there are sensors that measure his heart-beat and breathing patterns. All sensor information is wirelessly send to both Rosalita's and Jorge's mobile phones. If Louis is crying and bad-tempered with no obvious reason, the parents check Louis' condition in the mobile phone. If the sensor data values exceed certain threshold values, the mobile phone will alert it's owner.

In addition, Rosalita and Jorge have installed a movement and activity monitoring system in their home and backyard. The system includes activity sensors in walls, floors, and furniture, as well as in the garden. The system monitors vivid Louis' activities when he's awake and in sleep, whether he is inside the house or in the backyard. If Louis is trying to access dangerous places, for instance, to walk away from the backyard, the system alerts the parent at home by calling an alarm sound in the mobile phone.

The sensor and activity data are continuously collected to the hand-held device's memory and regularly send to a database on a server. When Louis is taken to the family doctor either for his regular examination or because of alerting symptoms, the doctor is able to check his health condition history from a year's time.

4.5 Housing scenarios

4.5.1 Moisture damage detection

In Pierre's house cellar, there has been a mild smell of mould for a few months. Pierre has finally decided to call a maintenance man to check the cellar and make repairing proposals if needed. When the cellar was built, tiny moisture sensors were attached all around inside the walls and floor. Although the sensors are hidden, the maintenance man is able to read their data of moisture with his mobile phone. The phone is equipped with a micro-projector, which projects a small display to the wall. The display visualises the actual location of sensors and the moisture value they detect so that sensors in wet locations show in darker colour than those in dry locations. With the help of the display, the maintenance man directly sees if there is moisture within the walls or floor and how it has been spatially distributed.

4.5.2 Erik and Maja's installation

Erik and Maja bought an ancient house for their family. They plan to renew the equipment progressively. At first, they want to renew the electric installation: they are interested in the installation of devices which can be controlled at distance to monitor the domestic risks, to economize heating and also to adapt the control of lightings according to their needs. The professional whom they chose visits their future housing. He estimates the importance of the works, the necessity of replacing some electric circuits, the possible difficulties of installation of the new devices. Erik and Maja speak with him about the features which they find useful: to command the luminaries in the living-room, to close shutters together or individually, to command blinds according to the wind or the sun, to switch off all the lights when leaving. Erik and Maja receive a plan and a description of the proposed works and a detailed estimation which they accept. Some days before the end of the work, the installer goes again to their house to commission the devices which he installed: he has a small mobile tool which contains the complete list of the products of the estimate, with the required features. He personalizes the products according to the need of his customers and verifies their functioning. By means of his mobile tool, he can directly know the exact characteristics of the devices. So he can check every command individually, modify it or repair a possible breakdown. He also shows Erik and Maja that their own mobile phone could be used later on, if they wish, to question a device and to get its folder from his after-sale service's web site. Maja asks him if he could also update the features of their TV and DVD according to the actual settings of the new antenna. So Erik and Maja could be helped to updating their devices progressively without the burden of understanding the difficult settings of each device.

4.5.3 Mary's home

Erik is worried about the health of his grandmother Mary. She lives in the same city, in another place. Soon 86 years old, she would like to continue to live at home on her own, in her district. Now, she always wears a small button of alarm which would allow her to call for help if necessary. But she had recently some worrisome incidents of health, a fall with temporary loss of knowledge, which entailed a hospitalization to make a physical examination. With the experience of their house, Erik and Maja say to themselves that they should advise to Grandmother Mary to improve the former installation of her old apartment. After all, doesn't she phone to them with a recent mobile phone, completely comparable to theirs, except the size of the screen which she chose?

By means of the Social Services Department of her district, they examine a proposition of kit " my Health at Home " which includes a part "my Health" consisting in a bracelet, either a brooch, to wear and a part " at Home ", consisting in four automatic switches, the control of

shutters and blinds for the sun, two detectors of gas and smoke and a water consumption meter. The profile of the functions "my Health" would be chosen by Mary with the advice of her doctor: for Mary, it could be a personal fall detector. It is so small it could be even incorporated into her small brooch "Blue Presence" which she already has! But maybe her diabetes will also require that she has a patch on the arm to allow a medical follow-up during some weeks? Mary is not very easy to convince, but she is going to discuss it with her doctor soon!

4.5.4 “Watch my door”

Maja and Erik have been living for some months in a new flat situated in the town centre. It is endowed with new features which they appreciate: nearby accessible services, natural space on terrace, concept "eco-climate" and so on. In general the system facilitates life. The front door, for example, has a function « Watch my Door » which avoids carrying a big bunch of keys and also simplifies the entrance to the building. When Erik goes out, he just has to present his mobile to lock the door of his apartment. If he hasn't his mobile with him, a discreet signal reminds him that the door is not locked: in that case, he can always use a mechanical key which he keeps in reserve. When he returns, he presents his mobile and pushes on the handle, which opens the lock. The access to the parking space, in the basement, is possible in the same way.

One of the advantages that they appreciate is to be able to welcome easily relatives or friends passing in the city. When they come to visit them, it is not necessary any more to leave them a key: Maja composes with "Watch my Door" a code of temporary access which she can pass on to them with her mobile. This summer, while Erik and Maja were travelling, they were able to accommodate a relative by giving him the code of access by the service of a secure e-mail. Naturally, in case of emergency, they could also give right of access to the guard of the building.

5 Scenario-Based Design

5.1 Scenario as a concept

Originally scenario as a term can be traced to the early theatre and/or film terminology. In this context scenario is a synonym to the screenplay, manuscript, copy or a script. Basic scenario elements are virtually same in the original notion and in the scenario definition applied as a method in human centred product development process. These basic elements include: actors (users), scene (context) and scheme (story including background, tasks, goals and action). Scenarios that include these elements and are used in human centred design can be more specifically defined as user scenarios, use scenarios, usage scenarios or interaction scenarios. Scenarios can also be called stories, narratives, and descriptions of user interaction or anecdotes.

Scenario concept is also typical to future studies where technical innovations, value shifts, geopolitical tides, environmental perturbations, economic developments, demographic patterns, and other trends of change are examined. Based on this data researchers create scenarios of possible alternative futures, which are then used as contingencies within strategic planning initiatives. In future studies scenarios forecast future under one or more affecting factors, rather than describe how people accomplish tasks like in scenario-based design.

In software engineering, the term "use case" is often used in a bit similar sense as "scenario" and these terms can easily be confused. A use case specifies the sequences of actions that a system or a subsystem performs when interacting with outside actor(s) (Jacobson, 1992). The external actors do not only refer to human users but also to anything that is outside the system and interacts with it. A use case definition is usually a short textual description of successive actions of the system and the external actors. The use cases help to identify and clarify the functional requirements of the system to be designed whereas scenarios focus on identifying user and contextual requirements. Thus scenarios tend to describe actions on a higher level, not focusing on details of actions like use cases. In human-centred design, scenarios are usually defined in connection to user requirements specification, and they are refined to use cases during the functional requirements definition phase.

5.2 Scenario as a design method

Scenarios can be utilised in many ways throughout the product development process. During the early phases of the design process scenarios can consolidate different stakeholders' view of the project. This way of using scenarios refers to future studies where scenarios are used for predicting the possible futures in various areas. Scenarios assemble the different views and know-how of different stakeholders and this information is combined with other possible factors (e.g. economical or demographic information, roadmaps for technology or behaviourist and cultural views of human beings). The common vision of stakeholders of the future is consequently shaped and presented as scenario(s).

Scenarios can further be used to collect the interests and know-how of different stakeholders as a starting point for the forthcoming activities and procedure in the project. In this way scenarios are applied as a tool to assemble a common picture of the projects' goals and aims as well as possibilities and limitations of the work to be done.

As a design instrument scenarios are stories about people and their activities in a particular situations and environments (contexts). Scenarios are user or usage stories about past, present or future. Scenarios can be textual, illustrated (e.g. picture books or comic strips), acted (e.g. dramatised usage situation) or filmed (e.g. videos) descriptions of usage situations. The users in these descriptions are usually fictional representatives of users (personas) but might also be real ones.

Scenarios can be used to describe current work practises or tasks of the users. Scenarios are written based on user interviews and observations. The scenarios help different stakeholders (including the users themselves) to understand the tasks in their context, to evaluate the practises and to suggest changes to these practises in parallel to designing new tools.

Scenario generating aims to predict how people could act in particular situations. That is why it is well suited for designing new product concepts, when the context of use and the intended users are not strictly defined. Scenario building is a flexible and cost-effective way to generate design ideas for new products and to identify the

potential user groups and contexts of use for the product. The design team can generate one or more ideas (or system concepts) for the new system. It is desirable to develop and compare several concepts. The most feasible concepts can then be selected to be further elaborated towards user and application requirements specification.

Scenarios help various stakeholders (including potential users) to understand imagined applications and services of new technologies. It is often easier and more fruitful to generate scenarios with a group of people rather than individually. That is why group methods, e.g., brainstorming, group discussions and focus groups are well suited for scenario building. Optimally the group should include people with different expertise, e.g. designers, end users, application field experts, marketing people and usability experts. In scenario-based design scenarios are used to capture and model external system behaviour as perceived by a potential user. Scenarios help identifying and describing potential problems related to the usability and utility of the system.

Involving end users in the scenario generating and refining process is vital to enable genuine user feedback for the system development as early as possible. However, scenario generation can also start without authentic user participation for instance when the project group first needs to agree on their common vision of the goals of the design.

The value of scenarios is that they make ideas more concrete describing complicated and rich situations and behaviours in meaningful and accessible terms. In this way ideas are easier to analyse and communicate. Scenarios help different stakeholders understand better the implications of particular design solutions especially from the user's point of view.

Scenarios can be evaluated with end users to find out user attitudes and needs. Both qualitative and quantitative methods can be used, depending on the goals of the evaluation. Qualitative methods give concrete feedback on the user actions presented in the scenarios whereas quantitative methods can be used to rank different scenarios e.g. in terms of credibility or acceptability.

5.3 Scenarios in MIMOSA

In MIMOSA project scenarios are stories or descriptions of usage situations in selected application areas. The scenarios describe the common vision of the MIMOSA project: 1) What MIMOSA technologies could provide to the end user and 2) how the technology will look and feel in different everyday situations. Scenarios are also used as a design instrument in the human-centred design process of MIMOSA technology and applications. The scenarios will be updated throughout the project, based on technology development and continuous user feedback.

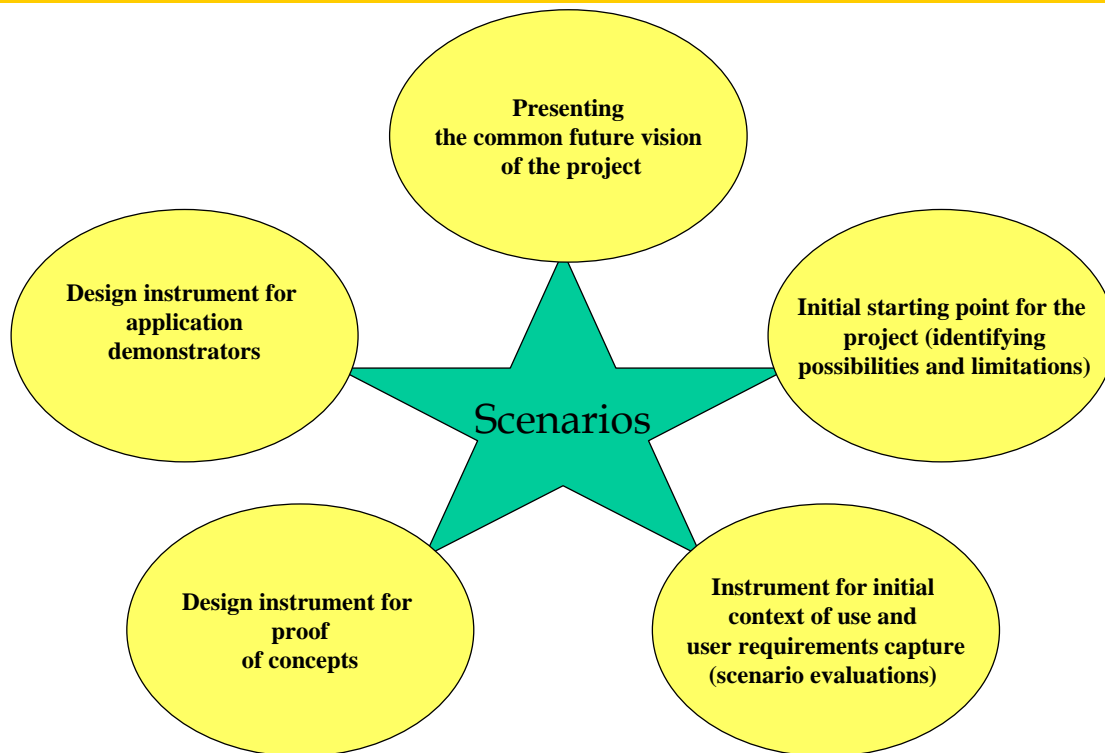


Figure 1. The role of scenarios in MIMOSA

6 Ambient Intelligence research State-of-the-Art

This review aims to present a state-of-the-art of Ambient Intelligence research concentrating on and categorised into the application fields of housing, health care, fitness/sports, and everyday – the application fields appropriate to MIMOSA. In addition, research on Aml interaction and interfaces is presented in a separate subchapter. This review partly overlaps the review included in the MIMOSA deliverable “D1.1 MIMOSA Initial Usage Scenarios” as much relevant research is still continuing. Those projects and research that are finished before this writing, are not included in this review.

Another objective of this review is to acquire an understanding of the conception of Aml as it currently is represented in research articles, project descriptions, visions, and scenarios. Furthermore, non-technological challenges related to Aml, such as privacy and social issues, are assessed.

6.1 Introduction

6.1.1 The conception of Ambient Intelligence

There is no strict definition of Ambient Intelligence, but it can be considered as a multi-faceted conceptual framework including technological, usage, user-related, and even societal aspects.

Ambient Intelligence is defined as visions and objectives – what an Aml application, system, or environment is for, and what should it be able to do. For instance, Aml should enable anywhere anytime natural access to IST services for all, as envisioned by the European Union Information Society Technologies framework program (ISTweb 26.8.2005). According to ISTAG, there should not be too hard attempts to define Aml considering the early developmental phase Aml currently is at and so to limit imagination, possible innovations and creativeness. Thus, Aml should be seen more as an emerging property, not as a set of specific requirements.

In spite of this view, the conception of Ambient Intelligence delineated by different contributors is quite convergent. The following features are typically more or less present in Aml visions, scenarios, scientific articles, and research project descriptions:

Invisible computers everywhere. Computing devices get smaller and smaller, and will be embedded in objects and surroundings. Furthermore, interaction with digital information will be available everywhere, for instance, through physical objects such as tables and walls with big touch displays embedded in them. The term invisible computing includes these both aspects – miniaturization of computers and their merging into normal physical surroundings (Norbert & Streitz, 2005).

Augmenting physical with virtual. This refers to the ability to get digitalized information and services from interacting directly with the physical environment. For instance, in the physical browsing interaction paradigm, the user can get object-related information by touching the object with her mobile phone (Välkkynen, 2005). Furthermore, computer displays can add virtual information straight to the user's sensory perceptions (Feiner, 2002, SciAm). For instance, special so called Augmented Reality eye glasses will give the surgeon a view into the inside of a patient's body.

Pervasive communication between devices. The computers and thus all kind of devices, objects, and surroundings will be fixed or wirelessly connected to each other so that communication between devices is either continuous or formed on an ad hoc basis whenever needed.

Convergence. Receiving all kind of information and performing all kind of digitalized tasks can be done via all types of media devices. For instance, TV can be used as a computer, radio, and game display. This is also called the cross-media approach.

Mobility. Due to pervasive communication of devices, a travelling user is able to seamlessly connect to ad hoc networks whenever needed, whether being in a building, at an airport, or in a taxi. As the user moves spatially, networking devices are dropped and other adopted accordingly, using always the connectivity best available in the current situation. The system is nomadic – it must allow users and computations to move around freely, according to their needs.

Sensing and context-awareness. Tiny sensors are embedded in the objects and surroundings, measuring different parameters for different purposes. For instance,

sensors in walls and furniture sense the number of people in the room, their position, activities, and mood, and perhaps their identity. Sensors in clothes and on the skin measure heart rate, respiration, perspiration, skin temperature, and even blood variables such as lactate level, for fitness, weight control, or health purposes. Sensors and sensing are the base for context-awareness of an Aml system, which allows the system to provide personalised and context-aware services.

Adaptation and proactivity. An Aml system should be able to adapt to the user's needs and preferences as well as the external context to operate flexibly and spontaneously. Some scenarios envision that the system should be able to be proactive, so that it anticipates and fulfills the user's needs before the user her/himself is aware of them. Both adaptation and proactivity require the system to make intelligent decisions based on collected contextual sensor data. The system should understand intentions based on context – enabling people to name services and software objects by intent, for example, "the nearest printer," as opposed to by discrete address.

Natural, intuitive interfaces. The Aml environment should be unobtrusive, relaxing and enjoyable (ISTAG, 2001). The user is not tied to sit in front of a computer display and use the clumsy keyboard-and-mouse interface to command the system, but the system should be able to understand human speech (in different languages), gesturing, and movements, and provide feedback visually in displays or in speech as well. Interaction with the system should be multimodal, utilizing more of human senses and ways of action than just vision and hand movements.

Outdoors a more suitable method for interaction may be a mobile terminal device, such as a mobile phone, PDA, or a wearable wrist computer. This would retain more privacy in the interaction event as interaction is initiated by pointing or touching items with the terminal device instead of speaking out loud or gesturing, and as information would be shown on the mobile display or heard through a earphones instead on some public screen.

Humane Ambient Intelligence

As a conception, Aml has emphasis on the user and even has a "social" and humanistic flavour – absent from most of the definitions of ubiquitous computing. For instance, Philips Electronics and Massachusetts Institute of Technology (MIT) define ambient intelligence as a marriage between the technologies of ubiquitous computing and social user interface (Ribauda, 2003). ISTAG (2001) states that Aml integrates three key technologies: ubiquitous computing, ubiquitous communication, and intelligent user friendly interfaces.

Furthermore, ISTAG (2004) emphasises the use of Aml for participation – facilitating the user's communication with social groupings, society, and business. The European social model will – according to the ISTAG vision – be modernised by Aml, in terms of improving civil security, providing new leisure, enhancing social groupings, facing the environmental problems, etc. Emphasising the social usage and benefits of Aml is also thought to precipitate the social acceptance of Aml. In line with that, although Aml is envisaged to be realized in all kind of environments and

contexts (by definition), current Aml research appears to be active especially in the domains of home and health care.

6.1.2 Enabling technology of Ambient Intelligence

The technology requirements for Aml are (ISTAG 2001):

- unobtrusive hardware – miniaturisation, low-power computers
- seamless mobile/fixed communications infrastructure – integration of different networks
- dynamic and massively distributed device networks – ad hoc configuration; middleware, agent technologies
- natural feeling user interface – intelligent agents, middleware; multimodality, adaptiveness, cross-media content; pattern recognition, speech
- dependability and security – robustness, self-testing, self-organising software; security against misuse, biometrics authentication

Infrastructure (systems and applications) for Aml must be long-lived and robust: fault-tolerant, highly available, and able to degrade gracefully (Streitz & Nixon, 2005). First, the system should be eternal – it must never shut down or reboot; components may come and go in response to demand, errors, and upgrades, but the system as a whole must be available all the time. Computers in this phase require naturally long-lasting power supplies and low cost structure.

Second, the system should be self-configuring, self-correcting and able to degrade gracefully. Challenges are found especially in *in situ* upgrade and update. Still another question is how to describe failure and its consequences (malfunctioning of the system) to the users when the infrastructure is invisible.

According to ISTAG (2004), the following Aml technologies still need significant research: smart materials, MEMS and sensor technology, embedded systems, ubiquitous communication, I/O device technology, and adaptive software.

Achieving the state of open standards is seen important (ISTAG, 2004). In Europe, the situation is that one or a few non-European companies will have the market dominance and become the only option for users. There is also a fear that this would jeopardize the idea of seamlessness. Because of that, large projects in which (European) companies, academics, and research centres collaborate to develop general **Aml platforms** are promoted. Examples of platform projects are MIMOSA (1/04-6/06) and eu-DOMAIN (6/04-5/07).

The EU-funded project eu-DOMAIN is developing an ambient intelligence infrastructure to facilitate mobile users and workers collaboration across Europe. The objective of the project is to implement a platform that will provide standardised ambient intelligent services through seamless ad hoc networking of terminal devices in any surroundings. The devices will be self-configuring using semantic agents. The system will provide location awareness using GPS services. Another aim of the project is to develop realistic business models utilizing Aml for users and service providers.

One step towards developing the Aml platform is to use a mobile phone as a media to Aml services, as is the objective of MIMOSA. Roussos, Marsh, and Maglavera (2005) list encouraging reasons for the mobile-phone based approach. There are over one billion mobile phones in the world. Potential services vary from ubiquitous information delivery and spatial navigational assistance to health care monitoring and diagnosis. Using a mobile phone as a universal control device is a technologically more realistic vision than that of automatic adaptation, both at and outside home. Mobile phones can be used as ID tokens – secure personal devices – which can disclose personal information when needed and that can be easily controlled. Finally, the mobile phone acts as a manifestation of Aml services, which makes them and the whole Aml system easier to conceptualize and interact with. All these reasons strongly support the MIMOSA approach to Ambient Intelligence.

6.2 Ambient Intelligence research state of the art

The presentation of the state-of-the-art of Ambient Intelligence research is categorised into the four application domains important to MIMOSA. The domains are Health care, Home and housing, Fitness and sports, and Everyday. In addition, the current state of research of Aml interaction and interfaces are reviewed.

6.2.1 Housing

According to the SWAMI deliverable (2005), the most important Aml functions at home are to facilitate communication between close people such as family members and friends, help in finding things and reminding of events and things, control home appliances, entertain the inhabitants as well as take care of safety and security of them. In addition, the Aml home network should allow personalized access to external information.

6.2.1.1 HomeLab/Philips

<http://www.research.philips.com/technologies/misc/homelab/>

Philip's vision of 'Ambient Intelligence' is that people are living easily in digital environments in which the electronics are sensitive to people's needs, personalized to their requirements, anticipatory of their behaviour and responsive to their presence.

Philips HomeLab research laboratory looks and feels like a regular home with modern furniture in every room, Van Gogh prints on the walls, and even a fully stocked kitchen. While no one lives at Philips HomeLab, temporary "residents" can stay at the facility for anywhere from 24 hours to two weeks, depending on the type of research being conducted. During their residence, individuals or families will go about life as usual, while interacting with the new technologies Philips has installed in the facility.

The prototypes range from electronics that recognize your voice and movement to digital displays within the bathroom mirror to new "toys" that help will children expand their creativity. For example, the use of unobtrusive and unnoticeable sensors is one of the pre-requisites of Ambient Intelligence. In *Sensechair* non-invasive sensing of human physiological parameters, such as heart rate (ECG) or muscle strain (EMG)

has become reality. The sensechair provides biofeedback to support people in achieving a more relaxed state. For this In an “Active Relaxation” application the sensechair makes the user’s heartbeat audible and synchronizes music playback to the heart rate.

Furthermore, studying how Ambient Intelligence can be applied to toys, while preserving their natural ease of use, may yield principles of user interaction that can be applied elsewhere. Toy-related technology also needs to be low-cost, setting it up for pervasive application without the costs becoming prohibitive. One of the technologies investigated is the emerging field of wireless sensor networks, which enable new functions and interaction styles. In HomeLab two toy applications are studied: *StoryToy*, an interactive storytelling environment, and *Splashball*, a mixed reality ball game.

Personal robotics is an emerging category of consumer products that we expect to play a major role in the connected home by supporting everyday access to devices and functions. Personal robotics can require research into appropriate applications, perceived personality and the software architecture for autonomous intelligent behavior. In HomeLab, a demo shows *iCat* as a helpful assistant in the kitchen. It combines information about the user’s calendar, weight and activity to give tips on what to eat and do, taking into account personal preferences.

Figure x. The socially intelligent iCat robot and its different faces for showing emotions.

Other examples of Philips ideas are PI@net, Phenom, Nebula, Easy access, Connected Planet and WWiCE (Philips, 2002).

PI@net demonstrates human focused solutions for enhanced informal knowledge exchange in real communities. Community members can browse, access, and create local content in everyday locations from internet-enabled furniture (like tables or community displays). They can gather and share their messages through Bluetooth-enabled mobile handsets.

Phenom: Perceptive home environments, is a project, which aims at creating an environment that is aware of the identity, location and intention of its users, and that eventually is capable of butler-like behaviour. An intelligent 'Memory Browser' system has been built and evaluated as a carrier application. The system recognizes multiple users, devices and objects, and learns from their behaviour. Interaction with the system is very natural: users can e.g. select photos using souvenirs. They show the souvenir for the Memory browser, which then offers to the user photos related to the souvenir. The project generates concepts and builds capabilities, particularly in system integration.

Nebula: ultimate relaxing; is an interactive projection system designed to enrich the experience of going to bed, sleeping and waking up. The aim of the project was to create an atmosphere that encourages and enhances rest, reflection, conversation, intimacy, imagination and play. Nebula consists of a ceiling projector linked via the Internet to a database of content. Once users have selected the content for

projection, they can manipulate it simply by adjusting their sleeping positions and interacting with their partner while in bed. Software translates body positions and movements into moving imagery and text. Since the dynamics between individuals are unpredictable, what the system displays will be a unique experience each time.

Easy Access project aims at developing user interface concepts for supporting users in accessing large databases of content. These databases could contain audio, video or other multimedia content. An Internet-connected audio jukebox recognizes its user, interprets tunes, which the user hums and then plays the song after finding it as digital audio content on a local CD or hard disk or on the Web.

Window to the World of Information, Communication and Entertainment (WWiCE) shows how an intelligent home might work. All devices in the home are interconnected. This enables someone at home to continue watching his favourite TV programme, as he or she moves from the living room to the kitchen. A virtual pet, in the demonstrator a little dog called 'Bello', is used on-screen as an interface. It listens to what is said and obeys the commands.

6.2.1.2 Aware Home

<http://www.awarehome.gatech.edu>

The Aware Home Research Initiative (AHRI) is an interdisciplinary research endeavor at the Georgia Institute of Technology that addresses challenges facing the future of domestic technologies. A unique resource in this activity is the Georgia Tech Broadband Institute Residential Laboratory, a three-storey, 5040-square-foot home that functions as a living laboratory for interdisciplinary design, development and evaluation.

The research themes span from supporting social communication to memory aids to everyday home assistants. First, technology can help to reconnect geographically distant extended family members by allowing them to remain aware of each other in a non-obtrusive, lightweight manner. In a *Digital Family Portrait*, a digital frame changes daily, reflecting a portion of a person's life. From general measurements of activity to indications of the weather, the portrait attempts to capture the observations that would naturally occur to someone living next door or in the same home.

Figure x. The primary Digital Family Portrait display (on the left) and the detailed display (on the right).

Memory aid research is looking at ways of enhancing people's ability to capture, archive and then access memories of everyday life. Projects are developing techniques for the semi-automated tagging of context with multi-media memory artifacts. *Memory mirror* is a system that keeps track on item usage. Each household item (e.g. medicine bottles, food containers) has a RFID tag on the bottom, and the designated storage area (e.g. medicine cabinet, key tray) has a RFID reader on the top. Each item is photographed and entered into the system's inventory. With this setup, the memory mirror system tracks the removal and return of each differently tagged object to and from the storage area. As an item is used, it is visually posted to

the calendar-like mirror display, and is recorded in a history log. The memory mirror also warns of possibly lost items that have yet to be returned to their place of storage.

In addition, the “Context-Aware Universal Remote” is developed to help people to control multiple devices throughout the house via one remote device.

6.2.1.3 Aml sink (Bonani & al., 2005)

The intelligent sink developed by Bonani & al. (2005) includes several Aml features. The HeatSink augments physical sink with virtual information, as water stream is colored according to its temperature. The context-aware SeeSink interprets visual objects/actions and sets the water temperature accordingly. For example, if the user shows a carrot to the sink, it will provide cool water for washing vegetables. The CleanSink attempts to ensure that people wash their hands (e.g., in a hospital) by providing feedback after the washing in the form of room lighting or access to a certain area. The interactive, reminding WaterBot conserves water by providing positive feedback and reminders when closing the water tap and by providing visual ways for comparing water consumption performance with other family members.

6.2.1.4 Discussion

The problem with many past smart homes projects has been that they primarily are technology-driven rather than demand-driven, as criticised by EMTEL (2003). The inventions in smart living have not so far been able to help with the most unpaid and time-consuming work of home, i.e. housework. While potential users have a set of similar needs for their homes, the context in which they are expressed varies widely. Homes are diverse in terms of physical design, layout and age, and people’s lifestyle vary considerably depending e.g. age and circumstances. The value-added to the consumer of a smart home is in its perceived benefit, not its ‘smartness’ or ‘intelligence’.

6.2.2 Health care

Aml research in the health care domain is much based on the future challenge of the aging population throughout the Western world (ISTAG, ?, u-Japan, uKorea, USA?). The age-related diseases such as cardio-vascular disease and cancer as well as cognitive decline of the elderly are predicted to increase, in addition to lifestyle diseases such as diabetes and obesity with its harmful ramifications.

The SWAMI project reviews health-related Aml research. Firstly, Aml applications can be developed for *prevention of diseases*, which requires applications and systems capable of continuous monitoring of health and health-related behavior, promotion of healthy lifestyle and related advice, alerting against dangerous products, and prediction of diseases (e.g., gene analysis). Secondly, Aml can provide support for *cure of diseases*, in the forms of diagnosis (video links, lab-on-chips), treatment regardless of time and place, ad hoc networks for information sharing, and facilitating drug delivery, automatic diagnosis of crisis and repairing action. All this requires continuous monitoring as well. Thirdly, Aml can provide help for *long-term care* by Aml for tracking activities, detecting anomalies, giving advice inoffensively, and enabling assisting technology. Again, continuous monitoring is needed.

Furthermore, Aml can help optimising the alarm chain in case of an emergency, providing supporting functions e.g., improving information exchange. For all this, sophisticated embedded sensor or actuator technology is required.

6.2.2.1 eu-DOMAIN

<http://www.eu-domain.eu.com/pn/index.php>

The eu-DOMAIN project is developing a platform for standardised Ambient Intelligence services through seamless ad hoc networking of terminal devices in any surroundings. The project has published two scenarios of health care to describe future diabetes patients' behavior when they are protected from the risk of catching a cardio-vascular disease. The other scenario will be implemented for demonstration.

In the scenarios, health monitoring devices such as a blood pressure device has a real-time connection to a network database holding personal electronic health records. The access for uploading blood pressure data to the patient's own record is granted on-line by the doctor. Clinical professionals can access the record details on-line. The database system produces a risk assessment from the patient's personal data.

When the patient borrows a blood pressure device from hospital, the device automatically configures itself at home according to the inhabitant, using a digital signature. When measuring, the device informs the doctor that it is operating, and the doctor is able to set up a monitoring scheme in the eu-DOMAIN intelligent network system. The system will monitor the patient via a range of house sensors, and in a case of a critical situation, it is able to make intelligent decisions relating to organization of assistance. The patient herself carries a PDA equipped with a feedback program, with which she can follow her condition and progress in the diabetes management plan.

In the other scenario, the patient has a wearable device for continuous measuring of blood glucose levels. Medicine (insulin) packs are attached with tags so that the eu-DOMAIN network system is able to record if the medicine has been taken. If the glucose level increases and insulin is not taken, the wearable device warns the user and, if no correcting action is taken in ten minutes, calls a care center. There are also movement sensors at home, with which the eu-DOMAIN system monitors daily activity. The wearable can also be used for communication with nurses in the care centre.

6.2.2.2 Proactive Health lab (Intel)

<http://www.intel.com/research/prohealth/>

The Intel's Proactive Health research agenda is called "Aging in place". Research focuses on the ways in which ubiquitous computing can support the daily health and wellness needs of people, who are suffering from cognitive decline, cancer, and cardiovascular disease, in their homes and everyday lives. Home health technology prototypes are tested with real families. Key collaborators include Intel Research

Seattle, the University of Washington, the Oregon Health and Science University, the University of Rochester¹, and Georgia Tech².

Current projects include *Activity Detection Technology*, in which prototypes of smart homes are being built and tested equipped with a network of sensors that track and monitor everything from cooking habits to purchasing activities to level and quality of physical movement. One potential outcome of this research is the early detection of the onset of dementia by monitoring changes in activity patterns and levels.

In the *Caregiver Relief Technologies* project, the same sensor network used for activity tracking allows a caregiver to take a nap or pursue other activities while the system monitors safety throughout the home. New communication technologies are also being explored that would allow remote households to participate in monitoring and, more importantly, providing social support from a distance.

The efforts of the *Adaptive and Distributed Interfaces* project are focused on adaptive and distributed interfaces, way beyond the mouse-and-keyboard setup, to assistive technologies within the home. The goal is to have a variety of interfaces-on telephones, televisions, PDAs or other electronic devices-distributed throughout the home, within easy reach of the person needing assistance.

Longer term, the hope is to create interfaces that can assess the current level of a person's cognitive function and adjust to provide the appropriate level of assistance. Given the day-to-day variability of cognitive function in many households, one day the system may only need to remind a person to cook, while the next day it may have to provide detailed instructions on how to prepare a meal.

The advanced smart-home system under scrutiny includes the following technologies. A *sensor network* for location sensing, using a combination of motion sensors, cameras, contact switches, magnetic switches, and Radio Frequency Identification (RFID) tags. A *home network* allows a household to interact not only through multiple, distributed touch points, including traditional PCs, PDAs, and tablets, but also through televisions, clock radios, and telephones. An *activity tracking system* uses dynamic Bayesian networks and other artificial intelligence (AI) technologies to translate all of the raw sensor network data into meaningful trending information about what activities people are doing in the home. *Ambient display technologies* allow distant family members to check in on their aging parents. For example, smart photo frames can show a person at-a-glance, and presence lamps turn on to let a person know that a loved one has gotten home safely.

Intel is also studying on wireless sensor networks to alleviate social isolation, inactivity and failing nutrition that is alarmingly common among today's aging population. In an example scenario, the wireless network monitors a single senior at her home via embedded sensors and alerts neighbors to join her when she is leaving home to go for a walk or starting to prepare lunch.

¹ Smart Medical Home

² AwareHome

6.2.2.3 Smart Medical Home (Univ. Rochester)

http://www.futurehealth.rochester.edu/smart_home/

The Smart Medical Home research laboratory is located within the Center for Future Health in the University of Rochester. The Center's overall goal is to develop an integrated Personal Health System, so all technologies are integrated and work seamlessly. This technology will allow consumers, in the privacy of their own homes, to maintain health, detect the onset of disease, and manage disease. The data collected 24/7 inside the home will augment the data collected by physicians and hospitals. The data collection modules in the home will start with the measurement of traditional vital signs (blood pressure, pulse, respiration) and work to include measurement of "new vital signs", such as gait, behavior patterns, sleep patterns, general exercise, rehabilitation exercises, and more.

This five-room "house" is outfitted with infrared sensors, computers, biosensors, and video cameras for use by research teams to work with research subjects as they test concepts and prototype products.

Figure x. The Smart Medical Home research laboratory is equipped with embedded infrared sensors, computers, biosensors, and video cameras

There are four concept (scenario) videos available at the website for the Personal Health System research (see Figure x).

Figure x. The Smart Medical Home overview (top picture). The Medication Advisor (bottom left). The Memory Assistant (bottom middle). The Smart Bandage (bottom right).

In the *Medication Advisor*, an intelligent system advises in a medication problems and personal health management via a natural conversational interface. The *Gait Monitor* system observes inhabitants' gait on the basis of video. The system analyses gait and seeks for early marks of neurological and musculoskeletal disorders such as Parkinson's disease. The *Memory Assistant* project is a video and display based system that is able to visually (?) recognize certain items that get easily lost (e.g., eye glasses) and shows their location in the house on the display on demand. The eventual goal of the Memory Assistant project is to develop smart memory prostheses.

The *Smart Bandage* is a sensor-based system consisting of inexpensive, lightweight biosensors for early detection of pathogens capable of causing human infection. For instance, when meat is cutted on a cutting board with a sensor embedded in it, the liquid from the meat gets on the sensor, which can be subsequently read and so get information of whether the meat contains salmonella. The sensor can be attached to a bandage as well to detect if a wound was infected with bacteria. A related *Biosmart Materials* project explores new packaging materials capable of signaling the presence of contaminating pathogens in food or beverages.

Another project, *Smart Mirror*, develops a mirror which allows 360° examination of skin to help identify problematic changes in its condition, such as early skin cancer. The mirror monitors changes over time and can alert user to seek professional advice if condition changes.

6.2.2.4 Philips: Reference Architecture for Care Everywhere (RACE)

Philips Reference Architecture for Care Everywhere (Philips, 2005) is a secure, personalized healthcare communication platform for patient management that remotely connects patients to their care community of professionals, support groups and family. When integrated with related personal-healthcare activities this will allow disease management, emergency response, post-discharge surveillance and safety and security monitoring for patients outside clinical institutions, for example in their own homes. Future developments will incorporate personal health-care appliances in the domains of self-care, prevention, and well-being.

6.2.2.5 Healthy aims

<http://www.healthyaims.org/>

Healthy aims is a project funded under the IST Microsystem programme that studies nano scale materials and sensors and microsystems for medical implants for improving health and quality of life of the aging population and those with disabilities. The mission of the project is to develop Intelligent Medical Implants and Ambulatory Measurement, 'Devices that communicate with the outside world, providing ambient intelligence to the human health level'.

Figure x. Pictures of Healthy aims research.

The medical products being developed include Cochlear implant, Retina implant and glaucoma sensor, Functional electrical stimulation for upper limbs (FES), Sphincter sensor for esophageal and urological applications, Implantable pressure sensor to monitor intracranial pressure, and Inertial Measurement Unit (IMU) for human body motion and to trigger the FES. In order to achieve this a number of key technologies are being developed including A Body Area Network (BAN) enabling communication from implants or on the body devices to a base unit which may be up to 3m away, Micro-electrodes, Micro assembly techniques, particularly for 3D structures, Implantable power sources, and Biomaterials, suitable for interfacing devices in and on the body.

6.2.2.6 SENSATION

The SENSATION project aims to explore a wide range of micro and nano sensor technologies to achieve unobtrusive, cost-effective, real-time monitoring, detection and prediction of human physiological state in relation to wakefulness, fatigue and stress.

The project develops a multipurpose sensing platform to assess physiological state of the user. The platform will be able to provide automatically a diagnosis about the

user's state. It will be intelligent in the sense that interpretation of the diagnosis will be performed by an intelligent decision making module and this information will be displayed to the user without any on-line intervention of an expert. The platform will be non-intrusive excluding wired sensors, and to be able to operate in non-constrained environment with a consequence that the sensors will have to cope with environmental non-controlled conditions.

The usage scenarios of SENSATION describe a sensor-based monitoring system that is very little automated do far. An example scenario presents how the system works in home-screening and diagnosing obstructive sleep apnea syndrome. The patient sleeps with sensors attached to a finger, a leg, a chest belt, and embedded to a night cap. The sensors wirelessly measure respiration, oxygen saturation, heart rate, sleep-wake state, arousals, and body position and movements. When going to sleep, a mobile phone like device is set by the patient to record data from the sensors. In the morning, the patient sends the data to the database at a monitoring centre for a clinical evaluation by a sleep physician.

6.2.2.7 Products on the market

The basic element of health-care scenarios, research, and products is constant monitoring of different health-related parameters. There are several monitoring systems in the market.

Figure x. WristClinic (top left), LifeShirt (top middle), SmartShirt (top right), Glucon (bottom left), and SenseWear Armband (bottom right).

WristClinic™ is a all-in-one wireless remote medical monitoring device for telemedicine and homecare applications. It enables timely intervention, disease and chronic care management, improved patient compliance and better patient care. Guided by a large icon-driven LCD menu, the patient activates WristClinic™ at pre-set times. Vital signs are measured, and data are transmitted wirelessly to MedicGate™ or MiniGate™ which forward the data by telephone or Internet to a telemedicine call centre or to an automated, web databank where the patient's medical record is accessible via e-mail, fax or personal computer. Optionally, measurements can be taken continuously and recorded on a continuous loop system. If transmission is disrupted, WristClinic™ will store up to 10 readings for transmission at a later time.

WristClinic's compact size makes it an all-in-one mobile medical device with strong consumer appeal. WristClinic™ facilitates fast, efficient clinical monitoring in home, office or travel environments. WristClinic™ has the following medical monitoring functions: Heart rate, ECG, Blood pressure, Heart rhythm regularity, Respiratory rate, Oxygen saturation (SpO2), Body temperature. The system records, stores and wirelessly transmits data up to 200 meters.

The VivoMetrics' **LifeShirt** System is a non-invasive, continuous ambulatory monitoring system that can collect data on pulmonary, cardiac, and other physiologic data, and correlate them over time. The LifeShirt System is based on a miniaturized, ambulatory version of inductive plethysmography (monitors breathing patterns) The LifeShirt System includes an integrated PDA that continuously encrypts and stores

the patient's physiologic data on a compact flash memory card. Patients may also record time/date-stamped symptom, mood and activity information in the recorder's digital diary, allowing researchers and clinicians to correlate subjective patient input with objectively measured physiologic parameters. Data can be uploaded via the Internet or data cards can be sent by courier to the VivoMetrics Data Center, where analysts and database specialists process and score the incoming data.

The SenseWear **Pro2 Armband** is a multisensor body monitor, worn on the triceps of the right arm. The system can be wore for up to two weeks and so allows continuous recording of physiological body signals, lifestyle and physical activity data to determine energy expenditure. The measurements are skin temperature, heat flux, galvanic skin response, and acceleration (movement) to derive different parameters informing the daily expenditure, physical activity, sleep efficiency and duration etc.

Glucon is a personal, non-invasive, real-time and continuous blood glucose monitoring device (not yet commercially available). Photoacoustics involves ultrasonic waves created by the absorption of light. These ultrasound waves are generated by illuminating the tissue with laser pulses at several selected wavelengths. Analysis of the acoustic signals can map the depth profile of the absorbance of light in the tissue.

Glucon uses Photoacoustics to map the influence of the glucose on the optical properties of the blood inside blood vessels. The acoustics element is used for the localization of the measured volume inside a blood vessel, as well as removing the influence of the outer layers of the skin. The optics element provides the specificity to glucose by using several light wavelengths.

The Company has already performed comparative tests on more than 60 volunteers and diabetes patients, in various clinical settings, and has shown glucose levels' measurements with excellent correlation to the current gold standards. Blood glucose level was monitored continuously, every 10 second by the Glucon device and sampled every 10-15 minutes by a reference device

The **Sensatex's SmartShirt System** is a wearable physiological information management platform that will have a profound effect on a large number of market segments requiring information and management of information generated from the human body. The SmartShirt is made using any type of fiber. It is woven or knitted incorporating a patented conductive fiber/sensor system designed specifically for the intended biometric information requirements. Heart rate, respiration, and body temperature are all calibrated and relayed in real time for analysis. The Health Monitoring System consists of three lead EKG, heart rate monitor, and respiration monitor. Other sensor features can be added. The information flows from sensors to either a personal controller or via other electronic means to interface for transmission to a monitoring station, physician or other appropriate location.

The current commercial systems appear to be wearable, non-penetrating monitoring devices for automatic recording and wireless transfer of the data to a PC or server, for instance. In regards to Aml features, the systems do not take context into account, and they do not provide any (proactive) compensation or prevention facilities. Their ability to adapt to the user is very limited and manually adjusted, and

the user interface may not be intuitive or natural (e.g., speech interaction is not available).

6.2.2.8 Discussion

Morris, Intille, and Beaudin (2005) analyse future Aml systems focusing to health-care at home. The critical functions a health monitoring system at home ought to have are embedded sensors monitoring, collection of longitudinal and context-sensitive data, and automatically process to detect important changes. Systems are needed for early detection of disease states. As people might be suspicious towards monitoring systems, Morris & al. (2005) state that integrating **monitoring** with **compensation** and **prevention** would help people to accept embedded health applications (this is called value beyond assessment).

Early detection of disease onset often fail because of the incompleteness of knowledge and delays in clinical diagnostic practices, and because humans have their individual psychological and behavioral patterns, for instance, they tend to deny or wait too long before contacting clinics. Also, journaling of frequent events (sleeping, eating etc.) is too demanding.

Monitoring systems are already on the market, but currently they provide no compensatory or preventive functionality. Monitoring should include different kinds of data in addition to “direct” data such as heart rate of blood pressure: data that is tied loosely to health (self-presentation, appearance, posture...) or health-related (eating and sleeping patterns...) are important.

Compensation applications could provide context aware computer reminding systems for overcoming interruptions, prompting for medication, helping to recall of names and faces, and providing feedback on social activity. Currently there are some prototypes but little field studies so far.

Systems for *prevention* would include “personal trainer” systems that provide tailored messages at teachable moments in order to motivate behavior, belief, or attitude change. Current technologies are far from this, e.g. websites for people vulnerable to particular illnesses, such as people at risk for obesity or diabetes.

People adopt better technologies for fun than for health management, thus systems should provide cognitive and physical exercise and motivating behavioral feedback. Potential adopters of these systems might be people in mid life, managing own health (family unit), and medical researchers searching for markers of diseases.

6.2.3 Fitness/Sports

6.2.3.1 Motion Aware Clothing

<http://www.wearable.ethz.ch/mac000.0.html>

The aim of the project (2004-) is to develop Motion Aware Clothing (M.A.C.) that is capable of monitoring and classifying body movements. The M.A.C. will be used as personal trainer and supervisor of body posture and movements providing feedback to the user (motivation and instructions for daily exercises and right posture) and data collection for diagnosis and therapy optimization (e.g. in rehabilitation).

One application is posture training, which focuses on people who want to improve their body posture in daily life, and on orthopedics patients who have to avoid certain postures and body movements. Another application of M.A.C. is movement training. This is important for people who need to perform physical exercises in order to improve or maintain their mobility and motor functions. Physical exercises can also be used for prevention of illness and for keeping a good condition (e.g. for elderly people). Intelligent clothing that acts as movement trainer will also have various applications in sports.

The Motion Aware Clothing M.A.C. unobtrusively integrates various sensors as well as computational and communication abilities in a textile. Signals paths and specific components such as elongation sensors and antennas are realized with conductive textiles whereas other components such as non-textile sensors or microprocessors are unobtrusively embedded in the textile. The goal is to develop a comfortable garment, which monitors body movements and postures of its wearer in daily life, gives motivation, instructions and feedback for exercises and collects data for the physicians (for diagnosis and optimization of therapy). Embedding of these functionalities in a common piece of clothing in an unobtrusive manner helps finding consumer acceptance and enables continuous monitoring in daily life.

6.2.3.2 Products on the market

The **Sensatex's SmartShirt** can be used for competitive athletes hoping to maximize their training and performance. The Athletic SmartShirt System allows the comfortable measuring and/or monitoring of individual biometric data, such as heart rate, respiration rate, body temperature, caloric burn, and provides readouts via a wristwatch, PDA/smart phone, or voice. Biometric information is wirelessly transmitted to a personal computer and ultimately, the Internet. <http://www.sensatex.com/>

The Project Fusion by Polar Electro and Adidas seamlessly integrates Polar heart rate and speed and distance monitoring equipment into Adidas sports clothing and footwear. Special fibers bonded onto tops work as a heart rate monitor and the sensor data is wirelessly send to a wrist computer. Stride sensors are embedded in the shoes.

<http://www.i4u.com/article3997.html>

Figure x. Sensatex's SmartShirt (on the left) and Polar Electro & Adidas' Project Fusion (on the right).

6.2.4 Everyday

6.2.4.1 EasyLiving / Microsoft

<http://research.microsoft.com/easyliving/>

EasyLiving is developing prototype architecture and technologies for building intelligent environments. The key features include computer vision for person-tracking and visual user interaction, multiple sensor modalities combined, use of a geometric model of the world to provide context, automatic or semi-automatic sensor calibration and model building, fine-grained events and adaptation of the user interface, device-independent communication and data protocols, and ability to extend the system in many ways.

6.2.4.2 MIT Project Oxygen

<http://www.oxygen.lcs.mit.edu/>

MIT (Massachusetts Institute of Technology) Computer Science and Artificial Intelligent Laboratory launched a project called **Oxygen** in fall 1999 with seed funding from the Defense Advanced Research Projects Agency (DARPA). Nowadays it is a project group, which have such partners as Acer, Delta Electronics, Hewlett-Packard, Nippon, Nokia Research Center and Philips Research.

Oxygen enables pervasive, human-centered computing through a combination of specific user and system technologies. Computational devices, called Enviro21s (E21s), embedded in homes, offices, and cars sense and affect the immediate environment. Handheld devices, called Handy21s (H21s), empower people to communicate and compute no matter where they are. Dynamic, self-configuring networks (N21s) help machines locate each other as well as the people, services, and resources. Software that adapts to changes in the environment or in user requirements (O2S) help people do what they want when they want to do it.

A scenario called Guardian Angel describes an elderly couple that is able to control their daily lives with the help of E21s, embedded devices. They no longer miss calls or visitors because they cannot get to the telephone or door in time; microphones and speakers in the walls enable them to answer either at any time. Sensors and actuators in the bathroom make sure that the bathtub does not overflow and that the water temperature is neither too hot nor too cold. Their automated knowledge system keeps track of which television programs they have enjoyed and alerts them when similar programs will be shown.

Tom uses the system now to jog his memory by asking simple questions, such as “Did I take my medicine today?” or “Where did I put my glasses?” The E21’s vision system, using cameras in the walls, recognizes and records patterns in Tom’s motion. When Tom visits his doctor, he can bring along the vision system’s records to see if there are changes in his gait that might indicate the onset of medical problems.

Oxygen has three visions of user technologies: Knowledge access, Automation, and Collaboration.

The vision for knowledge access is that people can access, anytime and anywhere, facts and other knowledge they deem useful in their personal and professional lives. A personalized repository organizes information of interest to a person, keeps track of how s/he accesses that information, and contains annotations about its relevance, quality, and comprehensibility. The repositories can be accessed in a personal way, by voice commanding, for instance. Also repositories that trusted friends and

associates are willing to share can be accessed. When people want still more information, they can access widely available knowledge, for example, in libraries or on the Web.

In the vision of automation, machine-to-machine transactions automate mundane information functions, as well as control of the physical environment, to suit people's wishes. Following scripted instructions, software agents handle appointments by fielding requests as they arrive by mail, by phone, or over the network, then consulting schedules and deciding whether to accept the requests, decline them, or gather additional information and defer the decision to the person. Other agents control environmental systems as a person enters a room to match her/his accustomed comfort level.

The vision of collaboration promotes computers supporting human-to-human collaboration across space and time. They help busy people get together for discussions and decisions, track their interactions, manage the flow of information among them, and document their decisions and the rationale behind them. Computers help people get together without annoying them with constant interruptions. Acting as personal assistants, they know when people are willing to be interrupted. When people want privacy, they intercept all but the most urgent (as defined by us) attempts to reach. When people are willing to be interrupted, they know how best to get their attention in ways appropriate to the location and task; Computers announce a visitor's presence by projecting a face on a display or sounding a gentle audio alert according to the user's preferences, waiting for an acknowledgment, and providing a gentle reminder if the user does not appear to notice. They help people initiate impromptu conferences by contacting other personal assistants to see who can be interrupted to join a conversation. And they provide records and summaries of the user's collaborations by automatically recording speech and video fragments, linking them to the materials and issues being discussed, and indexing them for future retrieval.

6.2.4.3 Ozone

<http://www.hitech-projects.com/euprojects/ozone/>

The Ozone project (2001-2004) investigated, defined and implemented/integrated a generic framework to enable consumer oriented ambient intelligence applications. The project sponsored by European Commissions under their Information Society Technologies programme. In the Pervasive'05 conference, the project published some everyday scenarios illustrating WSAMI, a middleware infrastructure for Ambient Intelligence based on web services.

In the scenarios, Aml services are used either via PDA or PC. A hotel room as well as a table in a restaurant can be reserved in the internet, in addition the user is provided with a virtual tour to the 3D-model of the restaurant. Friends can be chatted with in a messenger service on PDA. A movie trailer can be uploaded into the device from the movie service, and forwarded to the laptop that is a fixture in a cybercar, an automatically moving bus-like car for public transportation. The cybercar can be reserved in the internet, or an intelligent animated agent on the PC screen helps the

user to find transportation for trips. The interface is multimodal, working with both voice commands and using an electronic pen on the touch screen.

6.2.4.4 Car as a network-integrated mobile device

In short future, cars will be integrated with EVI (Electronic Vehicle Identification) ja ITS (Intelligent Transport System) systems. In EVI, a wireless data transmit device attached to a car will recognize the vehicle, its construction and equipment. Data about services and repair can be searched from networks, as well as traffic jam information can be sent to the driver. Lost cars can be searched by the help of the system. ITS devices help keeping safe distance to the car ahead, and call for help in accidents. (Kangastupa, 2005)

6.2.4.5 Project Aura (Carnegie Mellon University)

<http://www.cs.cmu.edu/~aura/>

Project Aura will design, implement, deploy, and evaluate a large-scale system demonstrating the concept of a “personal information aura” that spans wearable, handheld, desktop and infrastructure computers. Aura's goal is to provide each user with an invisible halo of computing and information services that persists regardless of location. The project studies every level to meet this goal: from the hardware and network layers, through the operating system and middleware, to the user interface and applications.

In a video scenario, the Aura system acts as an invisible secretary. The system can be communicated with normal speech with different languages, and it presents feedback on large displays on the walls.

6.2.5 Interaction and interfaces

6.2.5.1 Physical Browsing (co-authored with P. Väikkynen)

Coupling between digital and physical objects is a central concept of physical browsing. Want, Weiser and Mynatt (1998) propose bridging the gap between digital and physical by activating the everyday physical objects, connecting them with their virtual counterparts via various types of tags. Want et al. call these kinds of user interfaces physically-based user interfaces and state that the purpose of these interfaces is to *“seamlessly blend the affordances and strengths of physically manipulatable objects with virtual environments and artifacts, thereby leveraging the particular strengths of each.”* Want & al. have combined everyday physical objects, RFID tags and portable computing to create several example applications. The user interaction method of their work is simple, the user “waves” the tagged object near her tablet PC, which has a tag reader, and then some service is launched in the PC. Sample applications include sending email messages via augmented business cards, linking a dictionary to a translator program and opening a digital document via a physical document.

Kindberg et al. have created Cooltown, in which people, places and physical objects are connected to corresponding web sites. Cooltown utilises infra red (IR) and RFID

technologies to transmit web links to the users' mobile terminals. In Cooltown museum the visitor can gather links related to the display pieces and view WWW pages related to them. In Cooltown conference room the users can collect a link to the room at its door and access for example the printers and projectors of the room via the link. Kindberg et al. have also created eSquirt, a drag-and-drop equivalent for physical environments. With eSquirt the users can collect links and "squirt" them to other devices, for example "squirt" a previously collected link to a projector to display the corresponding web page.

Rekimoto and Ayatsuka have introduced CyberCode, a two-dimensional visual tagging system as part of their augmented reality research. They see visual codes as a potential tagging technology because of the increasing availability of cheap digital cameras in mobile devices and mobile phones. For example, links can be transmitted in a regular TV program, so that the user can point the mobile camera towards the TV screen and access the visual tag that way. In addition, drag and drop operations similar to Cooltown's eSquirt have been implemented, as well as using visual codes for identifying the location and orientation of objects in their augmented reality environments.

Toye et al. have developed an interaction technique for controlling and accessing site-specific services with a camera-equipped mobile phone, visual tags and public information displays. The users can interact with local mobile services by aiming and clicking on tags using their camera phones. Toye et al. have developed a mobile phone application, which displays the view from the camera on the phone screen, with tags highlighted. The user can then activate a link by clicking a button on the mobile phone when a tag is highlighted. This system can also utilise nearby public displays as a kind of "touch screen" in addition to the mobile phone screen – something that is only possible using visual tags.

Visual tags can be read with camera phones, of which Sharp (2004) presents some scenarios. For instance, when walking down a city street and seeing a poster for a movie, a visual tag on the poster can be clicked on by using a camera phone to get more information on the film. Additionally, there may be an option to buy tickets to the movie. Another example is, that an IT administrator could approach a rack of systems and quickly determine the configuration of each by aiming their camera phone at the visual tags placed on the various server boxes. The configuration details would immediately be displayed on his camera-phone screen, and using the phone's keypad he could scroll through and select the information that he needs.

The visual tags can be used as both active and passive controls. Active visual tags can be generated dynamically from a PC display (Figure x). Passive tags can be printed on posters or in magazines, for example.

Figure x. Active visual tags generated dynamically from a PC display (Sharp, 2004).

GesturePen by Swindells et al. is a pointing device for connecting devices. GesturePen works as a stylus for a PDA device but it also includes an IR pointer, which can read IR tags attached to electronic devices and transmit the tag

information to the PDA. The tag contains the identification of the device it is attached to so that the user can select the device for communication just by pointing at it.

Another physical browsing method is use a mobile phone or PDA with an attached tag reader to select tagged objects by pointing, touching, or scanning them. In the PointMe technique, the user selects a tag by aligning his mobile device towards the intended tag. In TouchMe, the tag is selected by bringing the mobile terminal close to it, virtually touching the tag. In the ScanMe selection method the user uses her mobile terminal to read all the tags in the environment. After scanning a result of the scan is displayed in the mobile terminal.

In addition to these user-initiated selection methods, active tags can also self-trigger communication. In this selection method called NotifyMe, the tag sends its contents to the terminal, possibly on the basis of context, and the terminal displays the information to the user without the user having to select the tag. A simple scenario involves the user walking through a shopping mall, passing several small stores, which send advertisement to the user's mobile phone.

Figure x. The techniques of PointMe (on the left) and ScanMe (on the right).

In addition to the aforementioned research projects, there is also some commercial usage of physical browsing. Hypertag³ is a commercial physical browsing system based on mobile phones and IR tags, which can send for example WWW addresses to the phones. Integrated RFID readers are appearing in mobile phones, for example Nokia has released an RFID kit⁴ and an Near Field Communication (NFC) shell⁵ for their mobile phones. NFC is a technology for short-range (centimeters) wireless communication between devices. The devices are typically mobile terminals and consumer electronics devices, but also smart cards and low-frequency RF tags can be read with NFC readers. There are four applications, as they are called by Philips: 1) "Touch and Go" allows simple data gathering from the environment or using the mobile terminal as a ticket or an access code; 2) "Touch and Confirm" lets the user confirm an interaction, 3) "Touch and Connect" helps in linking two NFC-enabled devices, making the device discovery and exchanging communication parameters easier, and finally 4) "Touch and Explore" allows the user or his device find out what services or functions are available in the target device. Interaction in Near Field Communication is based on virtually making the objects touch each other.

6.2.5.2 Speech and gestures

The Gesture Pendant project of Aware Home in Georgia Tech aims to develop an interaction device for controlling home appliances with a wave of hand. The Gesture Pendant system recognizes and then translates gestures into commands for home appliances.

³ <http://www.hypertag.com>

⁴ <http://www.nokia.com/nokia/0,,55738,00.html>

⁵ <http://www.nokia.com/nokia/0,,66260,00.html>

Figure x. The Gesture Pendant device.

6.2.5.3 Discussion

Weiser (1991) strove for implicit interaction whereas in physical browsing the interaction is very explicit. *To be continued?*

6.3 Non-technological challenges of Ambient Intelligence

Nowadays many non-technological issues are recognized as challenges or threats to the development of Aml. The questions of privacy, trust, and security were raised already by Weiser (1991), but are still topical. More recent questions concern legislation and especially diverse, large-scale social effects. All these will affect to user acceptance of Aml.

6.3.1 Privacy, identity, trust, security, and control

Threats to privacy are, for example, that lot of personal information will be transferred and stored in the Aml network and can be stolen from there. In addition, sensors everywhere enable surveillance of users. The AMBIENT AGORAS project has published European Disappearing Computer Privacy Design Guidelines (Lahlou & Jegou, 2004), which presents some useful although quite general instructions of how to take privacy into account in design of Aml applications and services. Weiser, 1991, cites Jim Morris from Carnegie-Mellon University and states that a fully secure and safe ubiquitous computing system not even necessary or possible. It is more realistic to think that harmful acts can and will be done, but the guilty persons can always be traced by digital fingerprints they leave in the system.

Other threats to Aml relate to digital identity, information which can be stolen from the Aml network and used maliciously, and security. Aml may make “intelligent” decisions that lead to harmful acts.

In many scenarios, Aml has a high level of control over security, privacy, communication, and even learning. Related questions include: Who will have the control over Aml? Who will maintain Aml? What if Aml makes wrong decisions? ISTAG (2001, 2004) emphasises that the user has to have control over the on/off switch of Aml.

Currently there are several ongoing projects dedicated to study privacy and related issues.

SWAMI (Safeguards in a World of Ambient Intelligence) aims to identify and analyse the social, economic, legal, technological and ethical issues related to identity, privacy and security in the forecasted but not yet deployed Ambient Intelligence (Aml) environment. The project will develop "dark" (adverse) scenarios, the aim of which will be to expose key socio-economic, legal, technological and ethical risks and vulnerabilities related to issues such as identity, privacy and security. SWAMI is an EU project (2005-2006). <http://swami.jrc.es/pages/index.htm>

Figure x. An example of an adverse Aml system (SWAMI). Cartoon by Jeff MacNeil.

PRIME (Privacy and Identity Management for Europe) addresses research issues of digital identity management and privacy in the information society. Its objectives are to develop solutions to empower individuals to control their private sphere and manage their identities, and trigger persuasive deployment of privacy-enhancing identity management solutions. The project will produce application requirements, including legal, socio-economic and usability issues, a public integration framework, a public architecture and specifications, and application-driven prototypes. PRIME is an EU project, running 2004-2008. <http://www.prime-project.eu.org/>

FIDIS (Future of Identity in the Information Society) focuses on research of identity and its protection. The project work is structured into seven research activities: "Identity of Identity", profiling, interoperability of IDs and ID management systems, forensic implications, de-identification, HighTech ID, and mobility and identity. Also FIDIS is an EU project, running 2004-2009. <http://www.fidis.net/>

PAW (Privacy in an Ambient World) develops a privacy protecting architecture that can provide full privacy of the user in an ambient world. The project takes a two-tier approach. To prevent unwanted collection of data about a user and his actions, techniques from secure computing are extended to provide private computing. To control the authorised dissemination of data about a user, licensing techniques similar to those used in digital rights management are studied. In particular, a private licensing language and protocols to handle and enforce such licenses will be developed. Ambient systems are characterised by their low resources and capabilities. PAW's key challenge is to develop an efficient architecture to implement our ideas. PAW builds on the results obtained during the PISA project. Funding for the projects comes from Dutch Ministry of Economic Affairs and TNO Telecom. The duration of the project is 2003-2007. <http://www.cs.ru.nl/paw/index2.html>

6.3.2 Legal aspects

SWAMI (2005) presents a legal viewpoint to privacy and related issues that are of importance in an Aml society. *To be continued...*

6.3.3 Social acceptance / digital divide / other social issues

Problems following implementation of Aml systems are yet seldom deeply thought and much less solved in visions and scenarios. The SWAMI deliverable (2005) raises several problems Aml may create, beyond privacy. Especially social issues have been receiving attention..

One problem is that scenarios are quite small-minded in their description of people: the actors in the scenarios are mostly white, healthy, working adults who are positive in their attitude towards use of Aml and technology. This is one sign of the digital divide, the division of people to technology-literate and thus successful, and the illiterate and therefore doomed to failure. The digital divide is not yet taken into account in current Aml approaches (SWAMI, 2005).

It has been claimed that for (mobile-phone based) Aml systems to be successful, they need to augment and enhance social communication and provide services such as localized dating, community building, file sharing, shared spaces, and mobile blogging (Beale, 2005). For instance, a social Serendipity system (Eagle & Pentland, 2005) facilitates social meetings between physically proximate people in everyday social settings, such as in a conference lobby, in the bus etc. The mobile phone and Bluetooth based system detects nearby system users and calculates a similarity score between any two users based on user-defined criteria. If the score is above some threshold, the system alerts the users with the other user's picture and a list of commonalities and talking points.

6.4 Summary

To be added...

7 Conclusions and future work

In this deliverable the Ambient Intelligence vision of the MIMOSA project in the form of usage scenarios is presented. The initial scenarios have been updated by using the material collected in scenario evaluations by potential end-users, interviews of experts, and workshops with MIMOSA partners. The updated ambient intelligence scenarios present more clearly real user needs. In addition, Ambient Intelligence visions and scenarios by other projects, organisations and scientific articles are reviewed as well as the conception and challenges of Aml. *To be continued...*

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