

Smart-Its child Surveillance System – SiSSy

Master of Science Thesis, 20p

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Abstract

In this thesis a description of what functions are necessary to support people with responsibility for children by using small computational devices for post-hoc computational augmentation of everyday things. The suggested solution, *SiSSy - Smart-Its child Surveillance System*, is an approach to tag children and parents with such devices that are context-aware and can sense the environment to determine whether a situation is dangerous. SiSSy makes use of Smart-Its, which integrate sensing, processing and wireless, ad-hoc communication and provides a platform for exploring ubiquitous computing. To collect information of how the system should be designed a group of possible future users was gathered to participate in a brainstorming workshop. The findings from this workshop were used as the user requirements for the SiSSy design. The conclusion of this thesis is that SiSSy has to be completely reliable for it to help parents and because of the inherent complexity of the problem; it is most likely that SiSSy will primarily be an experiment for exploring the Smart-Its concept. Smart-Its project is a collaboration of Lancaster University, ETH Zurich, University of Karlsruhe, Interactive Institute, Viktoria Institute and VTT and is a part of the European initiative The Disappearing Computer.

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1 Introduction

During the years as a student at the institution for informatics, I have developed a special interest for the interaction between humans and computers. Human behavior and sociology are subjects I also have studied and worked with for several years before I started my studies in informatics. When doing user-centric research within the area of informatics, Human Computer Interaction is a field of major importance.

Human Computer Interaction has over the last decade evolved immensely and changed what we see on the screen and what happens when you, for example, scroll with your mouse. Present operating systems and software have made certain tasks easier but sometimes “feel” as if they are doing more than required. These systems require a great deal of computer power compared to what was necessary just a few years ago. This may not be a problem since the technology continues to evolve very fast. The problem is, rather, within the usage of computer today. They are demanding and intruding as an artifact and to which we as humans have to adapt. If we look beyond the barrier of screen, keyboard and mouse, there is a whole new world of ideas of what computers might be capable of.

The American scientist Mark Weiser on Xerox’s Palo Alto Research Center coined the research field Ubiquitous Computing [Weiser, M. 1991] in the early nineties. The vision of Ubiquitous Computing has the ambition to relieve us from the demanding and intruding properties of the computer, get it out of sight - out in the periphery of our lives, while still being able to reap the benefits of computational services. Computers should conform to humans and humans’ needs, rather than the other way around. One solution for this is to attach computers to objects in the real world and connect them to each other to make them support people’s requirements whenever and wherever they need it. Ubiquitous Computing now seems within our grasp by the increasingly growth of computer power, smaller and more accurate sensors, greater communication bandwidth and less power consuming devices.

One research project that tries to realize some of the possibilities of Ubiquitous Computing is Smart-Its [Smart-Its]. Smart-Its is a project, funded by the Disappearing Computer initiative [DC] and the European Union, with the goal to make low-priced computational devices for post-hoc computational augmentation of everyday things. The Smart-Its devices integrate sensing, processing and wireless ad-hoc communication and provides a platform for exploring ubiquitous computing.

1.1.1 Purpose and Questions

Children disappear from their parents in shopping malls, crowded places and children even get lost from daycare. It is impossible for parents and personnel to have full control over what the children are up to, where they are going, and if there is more than one child - who is doing what.

The first notion of a Smart-Its system to help parents superintend their children came from the paper Smart-Its Friends [Holmquist et al, 2001]:

“...application for Smart-Its Friends could be a child monitor: By taking two Smart-Its enhanced objects, e.g. two brooches than can be worn by child and parent, and shaking them together, a connection would be established.

Whenever the child strays out of reach, the parent will get a notification.

The PLAY research group, Interactive Institute, has done research on ubiquitous computing for since 1998. Together with Peter Ljungstrand and Staffan Björk, researchers at PLAY, this work was planned and prepared. The Smart-its child Supervision System, SiSSy, is an approach to tag children and parents with Smart-Its devices which can sense the environment and determine whether a situation is dangerous or if the child is engaged in something hazardous. The idea is to make SiSSy easy to use without requiring any specific infrastructure such as large transmitting equipment or satellite communication. The system is by its nature primarily suited for children at an age between two and five years.

I will not question if there is a need for this kind of help for parents as it is almost an axiom that a good protection of our children is a priority. But there are other certain questions that have to be answered in order to achieve a good result.

While working with the SiSSy as a master project two research questions were formulated. The first outlined question was:

What kind of functionalities would be helpful for parents using such a device as the Smart-Its for monitoring their children?

The second question was:

Is it possible to design SiSSy with current Smart-Its technology or should we look at this idea as an experimental design within this area?

To answer these questions users have to be involved as participators for producing user requirements. These requirements create the foundation for the system implementation and will be the answer for the first question. When a prototype application is completed, the development process has to iterate back to the user for testing and finally to be evaluated. The evaluation will answer the second question and also find out if Smart-Its is the right design material for this type of application

1.2 Background

The Smart-Its project [Smart-Its] is a collaboration between TecO Karlsruhe, ETH Zurich, VTT Finland, PLAY Interactive Institute and FAL Viktoria Institute and is funded by the European Union's Disappearing Computer Initiative. The goal is to make low-priced computational devices for computational augmentation of everyday things with the size of a post-it note. Smart-Its will allow objects to perceive their environment, communicate with peers, and have adaptable and modifiable behaviors. Today the Smart-Its prototypes are big as a cassette box and fully functional. The vision of these devices is also for them to be as cheap, non-intrusive and as common as modern radio-tags so that they can be used to build and test ubiquitous computing scenarios by

augmenting a great number of everyday objects and places with Smart-Its. For both single smart artifacts and groups of these artifacts, the Smart-Its project explores behaviors and meaningful applications for objects with a computer-generated context-awareness. The aim of the research is to study collective context-awareness, scenarios and the feasibility of these kinds of applications. The Smart-Its project consists of two objectives that are described in the following sections.

1.2.1 Developing enabling and open ended technologies

One of the Smart-Its Project's objectives is to develop an enabling technology with no specific users or user groups [Holmquist, L-E. and Mazé, R. 2002]. Enabling technology is when research is open and with the purpose to create devices, systems or techniques that *enables* others to use in research or practice use. A good comparison is the open-ended desktop PC, which can be configured and altered for usage for a large number of different purposes.

The project started with inventing the technology and exploration of its potential and the applications were initiated from there. For example, what sensors were available for Smart-Its and what kind of information was possible to extort from them. Factors as processing and memory restraints as well as communication and battery power were also taken into account. The advantages of starting with designing the technology is that one can make the most out of the applications within the capabilities of, in this case, the Smart-Its technology. Within the limits of what the Smart-Its is capable of, we are now able to start inventing different kinds of applications that would work and bring the project forward. This thesis is not about designing the technology; it is about trying out new ideas for using the technology.

1.2.2 Explore appliances for Smart-Its technology

As a comparison to the technology approach there is the user- and task-centered approach where one looks at the users and the tasks they perform. What are their needs?

There are many available methods for this, for example ethnographical studies, interviews, etc, to clarify and study new user requirements. In this way there is a guarantee that there are users for the technology and applications and that it will be used.

The second objective of Smart-Its is to develop new applications for this new ubiquitous platform. The application research will investigate the emergent collective perception and context-awareness of ad hoc networked devices and to investigate user experiences. Although all project partners worked with both objectives, the PLAY group was more focused on the second objective, as can be seen in the following quote from their project homepage:

“Play’s objectives are to explore applications for Smart-Its technology in regards to context and user experience.” [PLAY]

To explore emergent applications for new technologies there is one fundamental starting point - get “out-of-the-box” thinking. We have to go beyond the usual thinking pattern and walk beside the beaten track. Doing this is a difficult thing to do and a tool is probably needed to achieve something. Tools such as brainstorming and scenario workshops have been used by the Smart-Its project. Briefly, there have been three application workshops that have shaped the basis of the application development process for Smart-Its. The application workshops made it possible to develop concepts which are matched for the Smart-Its platform and aims to make Smart-Its suited for real-world contexts and the user requirements.

There is however, always a certain degree of mixture between these approaches. Each approach must consider the other. It is impossible to create new needs without any real life factual basis. The result would probably be an application with no users. Likewise, it is impossible to design and realize technical applications from just user studies, without any consideration of technical potentials and limitations [Holmquist L-E. and Mazé, R. 2002].

1.3 Disposition

The disposition of this master thesis is:

Under the heading *Theoretical background*, important corresponding literature and theories will be brought up to lay a foundation for this thesis.

Related work, deals with previous and current research projects, which are relevant for the design of the SiSSy application.

Under *Method*, appropriate methods are brought up for this field of study. Explanations are given of why some methods are more adequate than others for this thesis and how required information was obtained. This chapter also works as a foundation for the accomplished workshop where parents took part in a participatory design workshop.

In the chapter *the Workshop*, a description of how the information gathering was completed is given. An interpretation of the gathered information is done to describe what functions are necessary to support people responsible for children by using Smart-Its

The design of the SiSSy gives the reader a detailed description of how the intended hardware and software application design is. A picture of the complete SiSSy is given as a system description.

In the next chapter, a *Discussion* is done regarding problem concerning the work with this thesis, choice of method and issues concerning the application as a whole. The framing questions for this thesis are also answered.

Finally, in chapter *Conclusion*, a summary of this thesis is done. It brings up the major and most important findings of the work.

2 Theoretical Background

The literature and the theoretical basis for this paper are summarized in this chapter. In chapter 2.3, this thesis main subject, Human computer interaction, will be entered more deeply. However, as this thesis is completed under the Institution of Informatics, an overview of the field is done in 2.1.

2.1 New Informatics

The research field of New Informatics, which is one of the bases for the education and research on the Institution of Informatics, University of Göteborg, is the foundation for this work. We live in an artificial world, Dahlbom writes [1999], and New Informatics is an artificial science because the interest is in artifacts. New Informatics does not resemble the natural sciences with their explicit interest in nature or the social sciences that do not dare approaching technology.

“Unlike the natural sciences with their explicit interest in nature, the subject matter of informatics is the world we live in, the world of artifacts, an artificial world. Unlike the humanities with its interest in understanding the past, informatics is interested in designing the future. And, unlike the social sciences that rarely dare come close to technology, informatics is not afraid of getting its hands dirty with scripts and protocols, since they are integral elements in the complex combine of information technology use.” [Dahlbom, B. 1999]

What New Informatics concerns is the interest in design and designing the use of technology. Informatics should be interested in evaluations of possible future fields of applications for the technology that develops today. Informatics has to be ahead of time because of the rapid development of technology and this means an interest in new ideas and contributions to the future [Dahlbom, B. 1999].

Dahlbom coins the conception of future archaeologists by drawing a parallel with to the traditional archaeologists [1997]; just as an archaeologist investigates an artefact from the past a future archaeologist investigates the future. We cannot foresee if the artefact ever will play an important role in influence our life but neither can the traditional archaeologist.

“An archeology of the future is just as scientifically respectable as an archeology of the past or present. The artifacts that we bring back from the future are really no less, or more, reliable as data than those we dig out of our past.” [Dahlbom, B. 1997]

With this viewpoint, this thesis is positioned under the science of informatics. What this thesis is all about, is trying to be ahead of time and contribute to the future fields of application as an example design.

2.2 Mobile Informatics

An important term for this thesis is mobility. Even though the research referred to below mostly is about mobility for work and falls under the research area CSCW¹, it is important to understand some concepts.

Being mobile is the state of being able to carry out work at different places, not at a fixed position. Mobility is of special interest for modern organizations where the work is team and project-based [Dahlbom, B. and Ljungberg, F. 1999]. Bellotti and Bly [1996] write about local mobility as something when people walk around in an office building etc. within the range for the local site.

According to [Kristoffersen, S. and Ljungberg, F. 1998] there are three notable varieties of mobility, called wandering, traveling and visiting. Wandering is to walk

¹ CSCW, Computer Supported Cooperative Work, is an academic research field, which deals with the issues of computer mediated collaborative work between multiple people [<http://www.cc.jyu.fi/~samuli/cscw2002/>].

around in an office building and working on different locations for short times for example IT support. Traveling means to travel in a vehicle as a satellite from the base unit, for instance radio reporters. Visiting is an activity where staff travels from one place to another and stays temporal but coherent such as IT consultants. The focus on work, as the mobile informatics usually has, is not the concern of the SiSSy, although, SiSSy includes aspects of visiting. The parents will be able to bring the SiSSy to use in different locations and use it there for a period. However, the SiSSy is intended to work without usage of any transmitting or communication infrastructures.

2.3 Human Computer Interaction

Human computer interaction, HCI, is the subject of how to design computer systems for supporting users to perform their activities easily and with high efficiency. The goal is to create usable, safe and fully functional systems. The term *system* in this case is taken from systems theory and does not just mean the software and hardware. It means the entire environment that uses or is influenced by computer technology, for example the organization of people at work, our home etc. [Preece, J. 1994]. Almost all of the major interface styles and applications are influenced from research at universities and labs [Myers, B. 1998]. Hewitt et al [1996] defines Human-Computer Interaction:

“Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them.” [Hewitt, T. et al, 1996]

HCI is an interdisciplinary research area and several disciplines have special concerns about this area each from different angles. For example computer science which deals with application design and engineering of human interfaces, psychology that deals with theories of cognitive processes and user behavioural studies, sociology which deals with the interactions between technology, work and organization, and industrial design which designs the interactive products [Hewitt, T. et al, 1996].

2.4 Ubiquitous Computing

The Ubiquitous Computing idea suggests that interconnected computer power will be distributed in our environment. Humans will be able to reap the benefits of computational services in more nuances when computers conform to humans and humans' needs, rather than the other way around.

The founder of ubiquitous computing, Mark Weiser writes about the three eras of computer use: the mainframe era, the personal computer era and the ubiquitous era. During the mainframe era one big computer served many people and throughout the personal computer era one computer serves one person. The next step in this progress is many computers serving one person and in this state, the computer has become ubiquitous. He argued that the desktop computer as we use it today is not a good tool:

“A good tool is an invisible tool. By invisible, I mean that the tool does not intrude on your consciousness; you focus on the task, not the tool. Eyeglasses are a good tool -- you look at the world, not the eyeglasses. The blind man tapping the cane feels the street, not the cane. Of course, tools are not invisible in themselves, but as part of a context of use. ...good tools enhance invisibility”
[Weiser, M. 1994].

His vision was to get relieved from the computer, get it out of sight - out in the periphery of our lives. Attach computers to things in the real world and connect them to each other to make them support humans on our conditions and only when we need it [Weiser, M, 1993]. Let the computational devices provide us with services and information when needed and where desired. In the ubiquitous computing era many hundreds of computing devices will be embedded in walls, clothing, cars, bikes, doors, sofas, chairs, tables etc and with others that may be used to access the Internet with. Ubiquitous computing is fundamentally characterized by the computational augmentation of real world artifacts [Weiser, M. 1996]. Weiser's vision now seems

within our grasp by the increasingly growth of computer power, smaller and more accurate sensors, greater communication bandwidth and less power consuming devices.

Abowd and Mynatt [2000] outline three key themes of ubiquitous computing today: *Natural* interfaces to support human expression in the computer interaction and use more of our implicit actions in the communication. People talk to each other and use gestures. We write with pencils to communicate with texts. These are ordinary and simple actions for people in a modern society and can and should be used as input to ubiquitous computing devices. *Context-awareness* for adaptable application behavior (I will enter this more deeply under 2.5 since it is a fundamental term for this thesis). *Automate the capture of live experiences* and provide an easy and ubiquitous access to these captures. In our life, we perceive and remember the events around us more or less correct. The not so precise recall function for us humans would greatly benefit from the computational augmentation of our memory. This is also a matter of a potential danger and of course threatens our integrity. Perhaps an augmented life such as automated capture of and access to can make us focus on activities that we are really good at, such as relationships, interpreting etc.

2.5 Context-awareness

Due to the importance of the term context-awareness for this thesis a thorough explanation is here given. First, we have to define context. Abowd and Mynatt [2000] writes that a complete definition of context is illusive, yet these five categories of context can help us understand what context is all about and how to make applications context-aware:

- Who is present? – Identifies the identity.
- What happens? – Identifies the activity.
- Where are we? – Identifies the location.
- When did/will it happen? – Identifies the time.

- Why are we doing this? – The comprehension.

Anind Dey [2001] writes that most definitions of context, such as synonyms for “context” or descriptive examples, are very difficult to apply and realize for developers. If a piece of information can inform us about a specific situation that an interacting user experiences, then the information is context. Dey wants an operational definition and defines context as:

“Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.” [Dey, A. 2001]

Dey also makes a quite general definition of context-awareness:

“A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user’s task.” [Dey, A. 2001]

For example, a context-aware indoor tour guide application has three apparent entities, the user, the application and the tour site. Looking at two different types of information, weather and the presence of other people, it’s easy to, using the definition, determine if there is context or not. In this case weather is not a context as the application is used indoors and does not affect the application. However, the presence of other people can be used to characterize the user’s situation and therefore by definition it is context.

3 Related work

There has been research for several years in the field of ubiquitous computing and many of its advances are relevant for this thesis. The different research projects that are presented here have in common that they are examples of context-aware ubiquitous

computing applications (with the exception of 3.1 and 3.5) such as the SiSSy. The first two, 3.1 and 3.2, are representative for earlier ubiquitous computing work. The TEA, 3.3, and the Media Cup, 3.4, are the Smart-Its predecessors. The Reminder Bracelet and Hummingbird projects, 3.5 and 3.6, are work conducted at PLAY and exemplify the notification issues and the awareness of presence. Finally, two projects within the Smart-Its collaboration that deal with the concerns of tagging humans. These two, 3.7 and 3.8, did not come to my attention before the majority of this work was finished, but are mentioned for completeness. All examples have been relevant for the development and analysis of the SiSSy application.

3.1 Tabs, Pads and Boards

This research, at Xerox Parc [Weiser, M. 1991, 1993], was based on the size of the computer devices. The devices, inch scale, foot scale and yard scale, were divided into these categories as they represented three significantly different scales of use from a human perspective. The tab was an inch size device and the user interact with it on pressure sensitive screen and three buttons. It has the ability to sense its position within a building. The pad was a foot-sized notebook device with writing and display surface. Pads are intended to be grabbed, used anywhere, and not carried around by its user. Similar to paper the pads could be spread out on a desk just as papers. The boards, yard-size displays could be used for different purposes in different environments, in the office as bulletin board, whiteboards etc and for input a wireless electronic "chalk" were used on the display. What they found out at Parc was [Weiser, M. 1991]:

“The real power of the concept comes not from any one of these devices; it emerges from the interaction of all of them. The hundreds of processors and displays are not a ‘user interface’ like a mouse and windows, just a pleasant and effective ‘place’ to get things done.”

3.2 The Active Badge Location System

The Active Badge system [Want, R. et al 1992] was a system for locating people in an office environment. Members of staff wore badges with transmitting capabilities. These provided information, through a network of sensors, about their user's location in the office to a centralized location service. The system was designed to locate people for meetings and for transferring telephone calls to the right location. For example, the Active Badge could be used in hospitals, which may require the latest information about the location of personnel and patients, especially for urgent situations. Tests showed that the system was accepted among the staff even though it implied some integrity issues.

3.3 TEA – Technology Enabling Awareness

TEA [Gellersen, H-W. et al 2002] is a project that investigated autonomous multi-sensor context-awareness device that would be available as a plug-in for mobile devices. The application idea was to add situational context to a mobile phone to improve the device's behavior for the user, make them smarter. The device integrates sensors resembling light sensor, microphone, accelerometer, skin conductance sensor and a temperature sensor. The vision of the prototype device was for it to be independent of the kind of mobile host to which it was connected. In experiments the TEA device was able to, with a certainty of 87%, recognize different contexts as in-hand, on-table, in-pocket or outdoors. They also implemented, with WAP-technology, the functionality for the caller to get information whether it is a good time to call or not.

They state that context beyond location can be “derived beyond the sum of what can be obtained from individual sensors” with the approach of multi-sensor context. They also found that audio, motion and light sensors work in various situations to obtain context-awareness while other sensors are more application specific.

3.4 The Media cup

The Media cup [Gellersen, H-W. et al 2002] project dealt with how everyday artifacts could be augmented with context-awareness. The idea was to create digital presence for the augmented artifact, compared to the TEA-project where the perspective was to improve artifact functionality. The artifact was not supposed to be “smart” and emerge itself as for the surrounding system environment. The Media cup is an ordinary coffee cup that is augmented with hardware and software to sense, process and communicate its context. The properties of the coffee cup were not compromised with size, shape or weight. It had sensors for movement and temperature, which made it, sense if the cup was still, drunken out of or just played with and if it was filled up or cooled off. With this application it is possible to, for example, determine if there is an informal meeting taking place, by noting that a lot of not moving, filled-up coffee cups are located in the same place. The main finding from this project is that services can emerge and support users once a framework for gathering and supplying information is in place.

3.5 The Reminder Bracelet

The Reminder Bracelet, Hansson and Ljungstrand [Hansson, R. and Ljungstrand, P. 2000] is a notification wristwatch like device connected to a PDA used for notifying scheduled events. The main idea with this device was to find new ways to get the user’s attention without disturbing the surrounding. The bracelet notifies its user using light, color and patterns. This illustrated a good and useful alternative to existing notification technologies. Personal devices such as PDAs, mobile phones and digital assistant risk to create an attention overload problem as the notifications from those devices often are obtrusive with bad timing. There has to be a trade-off between subtlety and functionality when designing this kind of notification technology to achieve a balance between these two qualities.

3.6 The Hummingbird

The Hummingbirds [Holmquist, L-E. et al 1998] are small devices that are designed to support presence awareness between members of a group located in the same physical area, i.e. an exhibition hall. The device, the hummingbird with the size of a PDA, notifies its user when other hummingbirds are in the physical vicinity with a 'hum'. This gives the group members regular indications of each other's approximate location. The initial requirements for the hummingbird prototypes were influenced by Weiser's calm technology [1996]. This is a technology that has to be active in the background without disrupting the user activities and minimize the level of interactions with it and eliminate the dependence on user interaction for functioning.

3.7 A-life: Smart-Its for Improving Avalanche Rescue

The idea for this project is to augment the avalanche beacons that exist today with the properties of Smart-Its. Sensors can provide information beyond location that is crucial for the emergency rescuers. Time is the most critical issue for the rescue operations and it would be of great help if the rescuers could obtain victim status so their time and effort could be focused on those victims that are not already dead or which are most critical. The current prototype consists of Compaq IPAQ for the rescuers as an interface and displays the sensor inputs. These are a pulse oximeter for measuring pulse and oxygen level, an accelerometer to sense in which position the victim is in and an oxygen sensor to determine existence of an air-pocket [Michahelles, F. et al 2002].

3.8 Unmasking Mister X

Unmasking Mister X [Antifakos, S. and Schiele, B. 2002] is a game in which a group of people has to find Mister X by approaching each other and compare displayed sensor values. Each player is equipped with a Smart-Its sensor board (see 6.2), and a PDA or a head-mounted display. The information each player has is Mister X' sensor values. They reveal the movement and the physical environment of Mister X. To unmask

Mister X the players have to check how the sensor values correspond to the environment and the activities other players. Different techniques for measuring distanced and light changes could give hints such as “cold”, “warm” or “hot”.

4 Methods

In this part, adequate methods used for this work are described and discussed to obtain a result as reliable as possible and to produce an implementation that is functional. How the different parts of the study were accomplished will not be discussed in this section.

4.1 Usability Studies

Usability studies are concerned with the evaluation of computer systems for making them easy to use and easy to learn. To help system designers build systems with good usability, the human-computer specialists have to *understand* the aspects that decide what makes people act in the way they do when they interact with the computer system. This knowledge has to be used for the *development* of tools and techniques to help designers ensure that computer systems are suitable for the user activities. This is to *achieve* efficient and safe interaction in terms of individual human-computer and group interactions. Behind all human-computer interaction research there is belief that the people using a computer system should come first. Their needs, capabilities and preferences for performing various activities are in focus. Interviews, observation, questionnaires, software logging, etc are different techniques for gathering information for evaluation of a system's usability [Preece, J. 1994].

4.2 Iterative design

The design process is always in a state of change and therefore has to be iterative and it cannot be seen as different static steps following the previous. When designing, new goals are often discovered, which have to be understood and valued. This is achieved by integrate testing and evaluations in the development process at regular intervals. The design is revised and redesigned according to the findings of the iteration.

The nature of iterative processes is that the specification is developed in conjunction with the system [Sommerville, I. 2001].

4.3 Participatory design

Mobile technology and Internet are today envisioned to make work seamless between different working locations. Iacucci et al [2000] suggest that situations of personal use should be considered as well when studying future mobile use. Factors as life style and culture seem to be an important influence for how mobile technology will be adopted and used. They also write that when designing for totally new situations of use there is a high risk to make wrong design decisions. To make these mistakes as few as possible it is valuable *“to iterate and keep the design-evaluation feedback as tight as possible”*. A way to do the latter is to keep the future users within the design process and for this purpose the techniques of participatory design has been developed.

Participatory design, also known as the Scandinavian approach, emphasizes the necessity of the involvement of the users in the design process, as they are subsequently the users of the system. The users provide frequent feedback to the designers throughout the development of system prototypes. This method is first intended to design large information system for organizations and the users participate by analyzing the organizational requirements and plan for appropriate social and technical structures to support both individual and organizational needs [Preece, J. 1994]. By involving these ”experts”, a collaboration is established where users can work together directly with designers in the development process. Their ideas for system improvements will be taken into account during the system development. The intention is to create a design that fits the way the end-users actually use the product in their work [Löwgren, J. and Stoltermann, E. 1998].

Löwgren and Stoltermann describe participatory design as mutual learning between the designer and the participating end user. The more one can understand each other the more participative the design process gets. This means that not only the users

take part of the design process also the designer has to get involved in how the user works [1998].

The participatory design method can be divided into several sub methods [Usor]. These vary from asking a user about a specific aspect once to having user representatives as collaborators of the project team. Some of these are more important for the development of the SiSSy:

- *Constructive Interaction*, this involves having two test users use a system together to perform some task and talking about it. The evaluator is recording the session in some way.
- *Focus Groups*, this method involve users discussing a certain problem under the supervision of a moderator. The moderator is responsible for maintaining the focus of the discussion on the issue of interest.
- *Future Workshop*, this method is a vision generator of the future use of computer systems. This workshop could be described as a structured brainstorming technique. A future workshop is separated into three parts: Critique phase, where participators talk freely about their work situation for framing problems about their work practice. Fantasy phase, where the outcome from the critique phase is converted into positive ideas, by imagining “what if” and how the work could change. Implementation phase focuses on what is realistic, from the result of the fantasy phase, for achieving changes and what are the required resources for this change.
- *Observation and Invention*, this is a scenario based method that uses different scenarios and observations of real users to envision and predict the future use of new products.
- *Thinking Aloud*, this is a very efficient way of getting many qualitative data from a user. The user should think aloud while performing some specified task

with the system. By expressing their thoughts, test users enable the designer to understand what they think of the computer system.

4.3.1 Role playing games

Iacucci et al [2000] used role-playing games in their research. The principles of the game is to let the participants act themselves in given situations. They examined different game structures, which are described here below. The numbers of players were 3-7 participants, which is not a fixed number, but perhaps more practical for the freedom to act. The story structure has its foundation from the user-studies, which involved information gathering from i.e. interviews, diaries and focus groups, or simply invented. The story structure can be very tied up or rather free which means that the group interaction can be very improvised or very predisposed by defined scenarios. The rules are different for different games, varying from no rules at all, just free improvisations, to defined rules for how and when the players should speak or act. Games to create scenarios for local mobility were played on a board game with physical representation of the environment for which the application is designed, in their case for example a campus. After five game tests were conducted they recommended a game with 5 participants, three actual players (future users) and two designers for keeping the game going, one of them a game master who checked the game rules were followed. They also found out that a carefully prepared game board with many details would give more accurate design ideas and increase the context awareness among the participants. They used incident cards to introduce events and vitality to the game that players were asked to pick up when needed. The following rules were also hung on the wall: *use always the toy character, act out the use of the device/service, use the dice to decide about non predefined aspects, everyone chooses a toy character and picks a "mobic" a mock-up representing a magic mobile device.*

4.4 My method

The method chapter brings out the methods that are relevant for this thesis. Methods used in the work are described in the order they were accomplished, but without any deeper descriptions as this is described in later chapters. The order of how things were done was as following:

- The first step was to collect information on the research field ubiquitous computing and context awareness. It is important to scan through related work to get knowledge of what previously has been done.
- The second step was to plan for the workshop and engage participators. This phase also involved a lot of reading to get inspiration of how to collect information.
- The third step was the workshop itself. The participants took part in a workshop that was a mixture of a future workshop and a role playing game. How the workshop was developed is described in this section, including the scenario sketches that exemplified how the technology could be used.
- The fourth step was to analyze the findings from the workshop and plan for how to modify the original design idea. This implies the design of the Smart-Its boxes and the interfaces with which the system is able to communicate the user.
- The fifth step concerns the documentation, evaluation and conclusion of the work with the SiSSy. This includes the work with finishing this master thesis.

5 The workshop

This chapter describes what functions are necessary to support people responsible for children by using computer-augmented artifacts. To collect information of how the system should be designed, a group of possible future users was gathered to participate in a brainstorming workshop.

5.1 Course of action

5.1.1 Prerequisites

Five parents took part in the workshop. They were between the age of 29-52, three men and two women. What was important on this occasion was not to create a too rigid framework for what is technically possible but at the same time, if the findings have no sense of reality, the workshop would be useless. The difficulty lies thereby in the task to convey the participators discussion to a relevant level for this thesis. The arrangement for the workshop was influenced from the work of Iacucci et al [2000] in the way of using a game board to represent a physical area, using toy cars and toy figures, and the number of participants and the use of me as a game master. This made it easier to moderate the session into the three phases of future workshops, critical, fantasy and implementation phases. And also, if the ideas would topple over and get beyond reality, the game master could guide the participators back to what is possible.

In order to make the players aware of the context it was important to use the game board map representing something familiar, in this case the obvious place was a playground. The playground is a place where children are relatively free to play whatever they want within a limited area. It is connected to other surroundings and doesn't always have physical boundaries such as walls and fences. This is a good place to do the tests as it allows the children to act and interact as they usually do. The limited area is also beneficial from the technology's point of view due to its somewhat restricted

functionality. The imaginary playground was based on a real world playground which could be used for the continuation of the SiSSy development. This would make it easier to motivate the children's parents to set off their time for participating since they can let their children play as any other day. This playground is located in the same neighbourhood as most of the children live. This compared with many other test places i.e. shopping malls, where a test such as this would be much more complicated to realize.

5.1.2 Scenario strips

A set of scenarios was created to illustrate how Smart-Its could be used in parent-child situations. These were simply made rough drafts of a situation, which just as a comic strip gradually change from frame to frame. This was a simple way to create a number of perspicuous scenarios and build the groundwork for the workshop with the participants. These scenarios also helped get a notion for what questions were relevant to ask. For example, what can happen? Is it possible to do that? Is it possible to implement this? How is the information routed correctly?

These pictures were also used in the workshop presentation to illustrate the intention of SiSSy and gave the participators a notion of the Smart-Its capabilities.

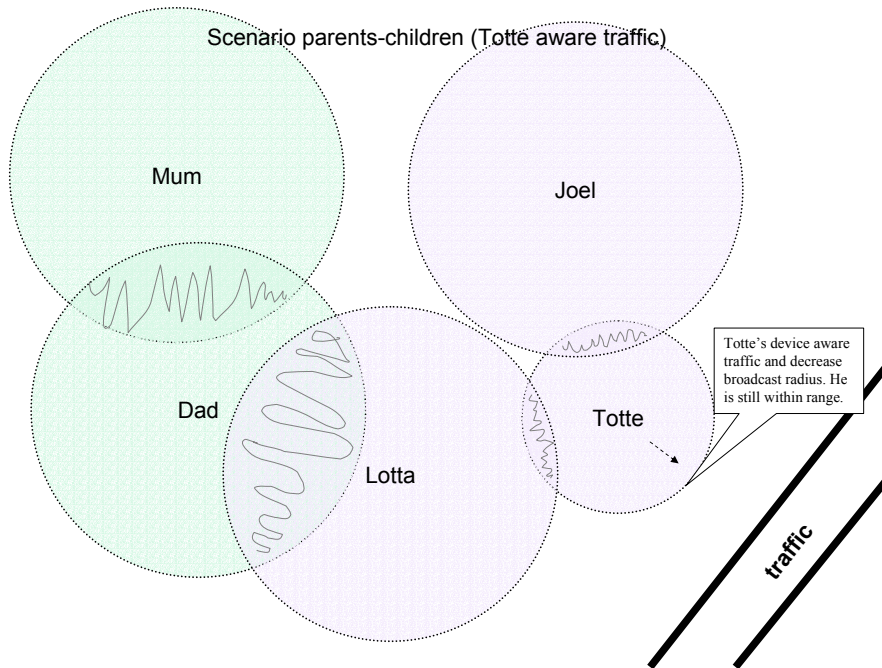


Figure 1: A scenario strip that shows what happens to the broadcast radius when a child approaches a motor trafficked road.

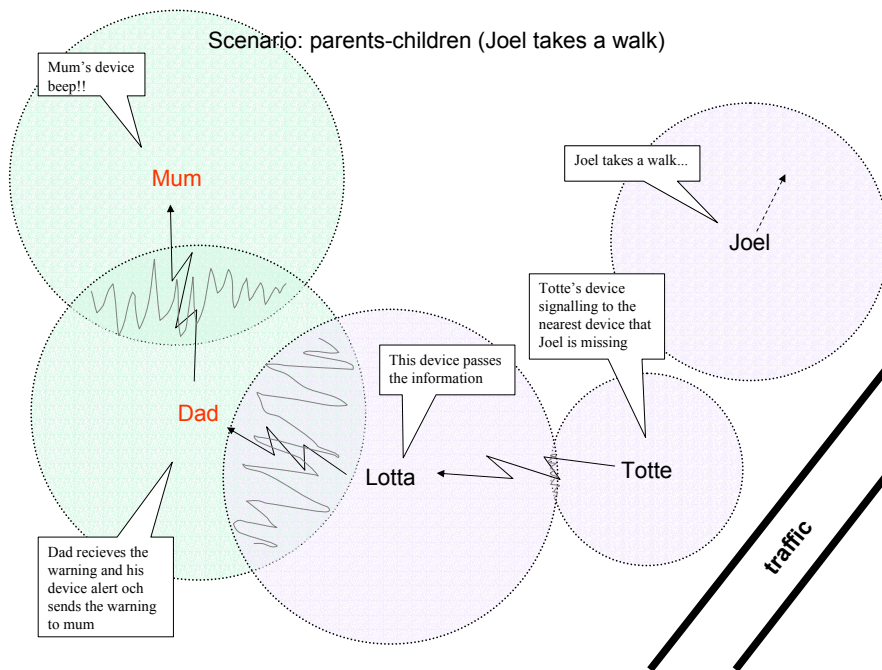


Figure 2: This scenario strip shows what could trigger an implemented alarm on the parents' devices.

5.1.3 The workshop accomplishment

The workshop took place at my home between 5 pm and 8 pm on an ordinary weekday. The session was documented with a video recorder to allow deeper analysis after the workshop. During the first hour the ideas of ubiquitous computing, the Smart-Its projects, the thesis and the goals of this workshop were presented. In the presentation, there was a brief discussion about the scenarios included. Before the discussion itself started, these two questions were presented:

- What functionalities are needed from a Smart-Its system for SiSSy to work properly?
- As a potential user, how do you think you would experience a system such as the SiSSy?

The discussion took off after the presentation and the first minutes were a bit fumbling but then continued in a very intuitive and spontaneous way. Difficulties concerning being out in a playground with children were immediately recognized. It was clear that the subject was very important for almost all of the participants. This was the critique phase. After some time they started to focus on what functionalities are necessities for them to use such a system. This was the fantasy phase. Some interventions from me as a game master were done but they were mostly answers technically related, such as “What kind of sensors are there?” or “How long does the radio signals reach?” etc. Finally, the workshop summarized the outcome and this was the implementation phase. The discussion lasted for approximately over two hours. The result is presented in 5.2. Note that the three phases of the future workshop were not static by any means, they had a very fluent character and the above grouping is very rough.

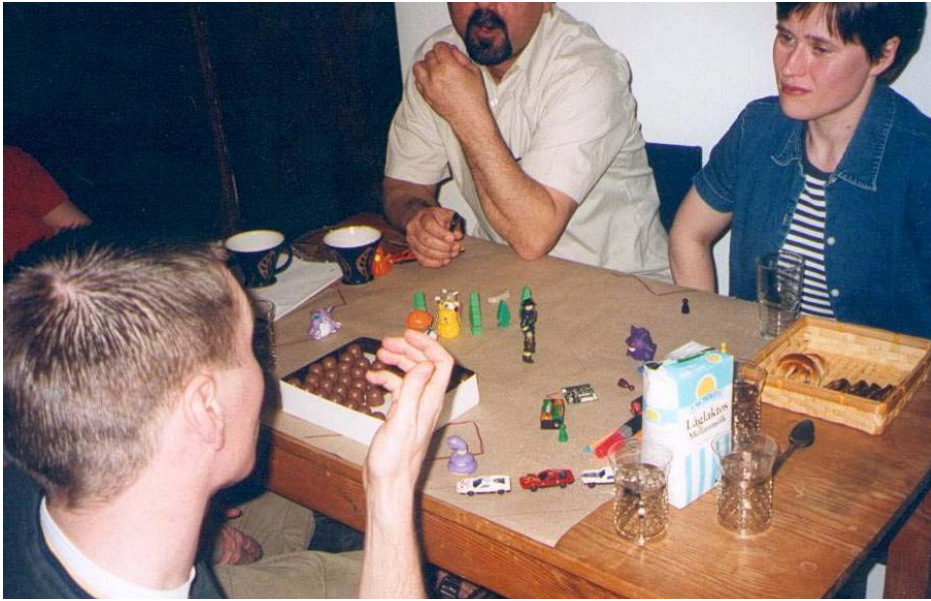


Figure 3: Participators enjoying coffee and chocolate with no intention to end the discussion.

5.2 Workshop result

The workshop generated a number of varied user requirements for SiSSy and some relevant criticism. The questions for the workshop were answered and the participants' opinions can be summarized as the following list. Note that each explicit requirement is followed by a short interpretation rather than an analysis of each requirement in detail. The analyze is done in chapter 6.1:

It is important that the SiSSy warn before anything has happened. It has to sense sudden and rapid movement away from other devices and the parent device has to alarm.

The interpretation of this requirement is that the system, with the help from the sensors, has to be able to decide when a child is moving, falling, climbing, etc in a way that might be hazardous.

SiSSy must be very reliable to have parents' complete trust. However, they recognized that if this is accomplished there might be a risk of parents becoming inattentive to what their children are doing.

With very reliable the participators meant that SiSSy functionality should not fail in a way that makes the users doubtful. For example, it is better if the system trigger the alarm without the child being in any danger than no alarm at all when danger is present. On the other hand, it is also important that the system not give the users a false sense of security as accidents actually happens even if a system seems reliable. They stressed the importance that this system just has to be for assistance and not for replacing the parents instinctive attentiveness and care for their children.

SiSSy should be equipped to sense moisture to prevent accidents in water, altitude to detect dangers of falling, and car exhausts to make it possible to decide whether the child is near traffic or not.

Beside the first listed requirement above the participators discussed the varieties of sensor combination. They all agreed that sensors to avoid drowning accidents, climbing accidents and traffic accidents were the most important to implement.

The behavior of SiSSy should be easy to modify. Different sensors can be used for different purposes in different situation and SiSSy should support this. It is more likely that SiSSy will be used if it works in more than one place.

When the parents are out in the playground, they can't see themselves doing hardware configuration of any kind. Therefore, SiSSy has to be simple to set up and use. For using the system on different locations there would be beneficial if different sensors matched the specific surrounding and this must be completely free from lengthy and detailed setup requirements.

Smart-Its could also be used for tagging the surroundings and not just for tagging children and adults. The benefits, with these "beacons", would be to

create secure and non-secure areas when a family is temporarily at a location e.g. in a playground, on the picnic etc.

Such Smart-Its beacons would dramatically increase the safety for the children but also make the setup a more complicated procedure. The beacons can be placed where the parents consider it to be a possible danger, e.g. a road or a construction area. It might also be of some help to tag an area that is safe, e.g. a playground.

There were also arguments for making SiSSy absolute position aware motivated by that if you can not find a missing child there is really no point with using SiSSy.

Some of the participants thought that using Smart-Its for this kind of application is not a very good idea as it can not be used for locating missing children as for example a GPS² would have. Because of this, the development of the SiSSy is just a waste of time, as it probably never will be used. This is a fundamental criticism on the idea of the SiSSy, which is discussed further in chapter 7.3.3.

Wristwatch-like devices with a vibrator alarm was suggested for the parents preferably with text messages that inform the parent about the situation, who, where and what.

The participators believed that their device should be a small thing, which was easy to wear. Preferable it would be a device with the same characteristics as a wristwatch. They also wanted the notification to be subtle as similar to sensing a vibrator against the wrist. When an alarm was required, the optimal information would be a digital display showing what most likely has happened and to which child. The parents also wanted to be able to stop a false alarm with a button. It is also interesting to note that PLAY has conducted research on a notification device, The Reminder Bracelet [Hanson, R. and Ljungstrand, P. 2000] similar to what was proposed on the workshop.

² Global Positioning System

As the system can not be absolute position aware the question *where* can not be answered. Again, this is discussed further in chapter 7.3.3.

The child device should be attached properly on the child's belt and must be silent. This to prevent any risk that SiSSy could cause disturbance in the psychological development for a child from being under surveillance.

When children play in a playground sometimes there can be quite rough games and the devices have to be attached thoroughly else it may fall off too easily. Children in the age between two and five often seem to have a good ability to take less comfortable things off, such as itchy hats and scarves, clumsy gloves, etc. Consequently, there are good reasons for designing the SiSSy devices in such a way to prevent this from happening. The participators made it also very clear that the children devices have to be silent. They believed that beeping and vibrating surveillance devices attached on them could cause a negative affect on children's mental development.

6 The Design of the SiSSy

Under this heading, a detailed description is given of the intended hardware and software design. Explanations of the hardware limitations and why some of the user requirements are not possible are also addressed. A picture of the complete SiSSy is given in chapter 6.5, System description.

6.1 Analyze

In short, the users want SiSSy to warn parents if their child or children are doing something that might lead to an accident, e.g. drowning, car accidents and falling from high and steep rocks. They also want SiSSy to be ergonomic and practical to wear for both parents and children and the notification should be subtle and non-irritating for the surrounding. In addition, it would probably be beneficial for SiSSy if some devices could be used as beacons for marking out an area.

For this thesis, it is impossible to build in Smart-Its devices into a watch. Therefore, we have to accept the parents' devices to be a two-piece device, with a wristwatch as the interface, connected with a cable to the actual Smart-It, attached on the parents arm. To make the system flexible it has to be able to route information through intermediate devices. The benefits for this would be that parent devices would get information from the children devices about other children, which are out of the parents' devices' range. It would also make it possible for parent devices to leave the situation for some errands. For example to go and buy some hotdogs, without its alarm triggering as it "knows" through the routing protocol that the other parent device has the situation under control. This could however be a disadvantage, as the routing functionality inherently requires more time in order to receive information through intermediate devices.

The devices should have adaptable behavior, which means it has for example increase and decrease broadcast radius depending on the context it senses. This could be an approach for trigger the alarms instead of broadcast sensor input or warnings. If the

child is doing something unsafe or something hazardous is getting closer, e.g. a car, the broadcast radius decreases and the child comes out of reach. The alarm goes off.

Constraints on sensor accuracy and sensitivity, memory size and processor speed defined what a SiSSy device in reality could achieve. For example, even if there are algorithms that can selectively sort out traffic noise from the surrounding with high certainty it would probably require more powerful computation devices than Smart-Its. However, the TEA project [Gellersen, H-W. et al 2002], 3.3, writes that typical indications for different kinds of audio are the number of zero crossings of the signal in a certain time, which indicates the number of direction changes of the signal. This might be a solution for Smart-Its to detect traffic. However, how accurate this could be for the SiSSy is a question impossible to answer without real testing. It would perhaps detect traffic noise and trigger the alarm but the baa from sheep may also do this.

6.2 Smart-Its description

The Smart-Its prototype [TecO] used for SiSSy is designed and manufactured by TecO Karlsruhe University and consists of two main boards: a RF-board equipped with an 868.35 MHz transceiver and a sensor board that can detect sound (using a microphone), touch pressure, light level, 2-dim acceleration and temperature. An I2C bus connects the boards together and both boards are equipped with a microchip PIC processor at 20MHz, 13 Kbytes Flash program memory, 386 byte RAM and 265 byte EEPROM. A PICC-compiler and C-programming language is used for programming the microchips.



Figure 4: The Smart-Its boards, to the left the sensor board and to the right the RF-board.

The Smart-Its developing environment consists of MPLAB by Microchip Technology, a PIC C compiler from Custom Computer Services and a Galep-4 programmer. Advanced code for the fundamental properties of Smart-Its, such as the wireless and ad-hoc communication protocol, the I2C communication between the boards and the sensor management, was provided from the Smart-Its Project collaborators TecO in Karlsruhe and ETH in Zürich. In addition, example application code was at hands and software libraries were developed for controlling the sensors and for sending and receiving packets. The sensors intended in the SiSSy application are the accelerometer for detecting movement, the microphone for sound detection and the light sensor for detecting intensity of light.

6.3 The Smart-Its box

The Smart-Its box consists of the RF-board and the sensor boards together with batteries in a cassette box, with the size 11 x 7 x 1.5 cm. The Smart-Its box was in fact designed for the project within Smart-Its called *Smart-Its go to Dinner: Scenarios for Context-Aware technology in Restaurant Application* [Mazé, R. et al 2002] that were



Figure 5: Three Smart-Its boxes ready for use. The transparency of the boxes is necessary as the boards contain various visual actuators.

worked out at PLAY. It is designed to be a rechargeable device with connectors for programming and debugging and to connect external devices. The RS-232 interface and the I2C-bus are drawn out to the connectors for easy connections when more functionality is needed. This solution is inexpensive and robust and was not specifically designed and developed for the SiSSy application in mind. However, the workshop findings influenced the construction in the sense that the box is flat which is ideal for the SiSSy application, as it will be attached to child's belt. It will also be very easy to attach on a parent's arm.

6.4 The wrist-watch interface

The wrist-watch device requirements illustrates a device with a text display that can show more detailed information of what has happened, to whom and where it happened. Buttons were also desirable to stop a false alarm and may be useful for some basic configuration possibilities, for example, adjusting the notification characteristics or the SiSSy's context sensitivity. The display properties would probably be best showed by a LCD display or likewise but within the frames for this thesis it was considered not to be the best solution. An easier way to build the desired interface would be to use four diodes and vibrators but with the cost of some user information i.e. the information of what has happened and where and the obvious limitation of testing on no more than four children.

The watch is put together from the casing of a dismantled, inexpensive voice-recorder watch with two rubber buttons, one cut out experiment card, one I2C circuit, four diodes (blue, green, yellow and red), two switches, a vibrator and some resistors



Figure 6: The wrist-watch device is here signaling that the "blue child" is in trouble.

and cords. The result is a small round device, 4 cm in diameter and 1.5 cm thick (see figure 7), with a mirror glass look. It can vibrate, provide four different colors on its “display” and it is possible to implement functionality for the two buttons. A five-cord flat cable is attached to the watch for connection with the Smart-Its device. The cable is used for sending, receiving, voltage and IRQ (the fifth is not connected) to control its functionality. Two copies of this prototype were made and the look and feel of these was comparable with the original.

6.5 System Description

The system description of SiSSy explains how the system is supposed to work after the limitations of the Smart-Its’ capabilities is taken into account. SiSSy is supposed to be used where parents and children are being together for helping the parents to supervise their children and prevent accidents. The system consists of three types of devices: parent devices, child devices and beacon devices. They all have the same capabilities but different purposes and characteristics. Additionally, the parent device has a wrist-interface connected. The prototype wrist-interface is able to show information of four children, which limits the number of children in the system. Of course, such limitations are undesirable in, e.g. commercial products.

The parent device is the only device, which has the ability to notify its user and the only device which the user directly can control, when using the button for resetting the alarm. This device will emit a question



and if it does not get answers from all of the child devices the alarm will be triggered, starting to vibrate and showing the color of the missing device, i.e. child. The alarm

could also be triggered when a child device emits an answer containing an alarm-trigger-bit. For making the system not too “nervous”, which can raise the users’ both irritation and distrust, a certain amount of delay before the alarm is used can be motivated. This means that the parent device will allow some answer loss from the child devices.

The child devices, which are attached on the children, are fitted in a mobile phone case with a belt clip. The child devices will be in different colors matching the diodes on the wrist-interface, i.e. blue, green, yellow and red. The child device does only react to context from where danger can be derived. For example, a distinct situation would be when a child suddenly starts to run, which the accelerometer can sense, and at the same time the microphone detects sound which is likely produced by a car. This makes the child device start to answer the parents question with an added alarm-trigger-bit. Another example would be when something comes in the way between the child device and the parent device, which makes the parent device unable to receive the child’s answers and consequently the alarm goes off.

The beacon devices are supposed to be attached in the surrounding as corners of an area, which is supposed to be under extra surveillance. These devices are to increase the system’s reliability. It will have the same routing and sensing



functionalities as the other devices but it has two different states, danger or safe, which is constantly emitted. The states are dynamical and adjust after its context. It will also be possible to configure them to have static states. For example, the beacon has one green side and one red side and whether the power is turned on with the green side up the state is “safe” and with the red side up the state is “danger”. Any of the four other sides upwards will start the SiSSy beacon in the dynamical mode.

6.6 UbiComp 2002

A student poster describing SiSSy [Jernström, H. 2002] was accepted for UbiComp 2002 conference [UbiComp] held September 29 - October 1 in Göteborg.

The Disappearing Computer Initiative [DC], which is funding the Smart-Its project, also had a two-day long exhibition at the same location as the conference. The SiSSy was represented in the Smart-Its showcase with a video showing scenarios of how the SiSSy is intended to work. The reactions on the idea of the SiSSy can be divided into two categories. One group believed it was a good idea and from which interesting problems can be extort from and solved. The other had a very pessimistic attitude towards the idea since it can not help parents to find their children and thereby of no use at all. It seems that these researchers have misunderstood the idea since the criticism is concerning the lack of location-awareness in the system, i.e. Smart-Its has not location-awareness implemented at all, rather than questioning the reliability of the context-awareness capabilities. A parable would be to consider the automatic fire alarm useless as it can not be used for fire fighting purpose, rather than questioning its ability to sense smoke.

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The goal of the Smart-Its project is to make small computational devices for post-hoc computational augmentation of everyday things. The Smart-Its devices integrate sensing, processing and wireless, ad-hoc communication and provides a platform for exploring UbiComp. The Smart-Its Surveillance System, SiSSy, is an approach to tag children and parents with devices that can sense the environment and determine whether a situation is becoming dangerous. The Smart-Its project is funded by the European Initiative *The Disappearing Computer*.

The idea is to make SiSSy easy to use without requiring any specific infrastructure. To find the relevant functionality I arranged a brainstorming workshop with five parents. A map of a playground was used together with small toy figures exemplifying children and parents. The findings were:

- SiSSy has to warn before anything has happened and the parent device has to alarm.
- The behavior of SiSSy should be easy to modify for use in different environments.
- Wristwatch-like device for the parents with a vibrator alarm that informs the parent about the situation, who, where and what.
- SiSSy must be totally reliable to have parents' complete trust.
- SiSSy should be equipped with various sensors to make it possible to detect possible dangers.
- The child device should be easy to attach on the child's belt and must be silent.

Smart-Its could also be used for tagging the surroundings to create secure and non-secure areas.

The system will be able to route information through intermediate devices to make the functionality more flexible. The first SiSSy ready for use will be evaluated by the same parents who took part in the above described workshop. The test will be carried out on a playground similar to what the workshop map represented.

<http://www.smart-its.org>

7 Discussion

In this chapter, a discussion is done concerning the problems and findings this thesis has encountered, also choice of method and issues concerning the application as a whole are discussed. The framing questions for this thesis will also be answered. The heading future work will end the discussion section.

7.1 Detailed problems

Here, an inspection is done to clarify exactly what has gone wrong, and the efforts for to making the effects of these as small as possible, in order to achieve this thesis.

The Smart-Its delivery were first planned to arrive at PLAY in late February. The delivery was then postponed two weeks at a time until the delivery in the middle of May. This made the development of the SiSSy delayed approximately two months. During this waiting time the workshop took place and the analysis of it was done. In late May, the work started with building the Smart-Its boxes and in August the wrist devices.

There were as well problems with the configuration of the development environment which took a long time to solve. The problem consisted of that some of the functions simply did not work when testing the Smart-Its. The fault was quite delicate and hard to get a grip on. After two weeks, in August, the fault was found which was that the binary files the used compiler created were different from the binaries other compiler versions created. Search for errors is also time consuming work as it takes five minutes to re-program a Smart-It, for each board.

During the planning phase of this thesis, some apparent areas where extensive assistance was needed were identified. As this assistance did not appear, due to low priority, for example, the more complicated parts of the programming have not been implemented as planned. What has been done so far, with code from ETH Zürich as starting point, is implementing for sending packets between devices containing sensor

values from the accelerometer, thermometer, microphone and light sensor and pressure sensor. The parents' wrist-interface is fully functional in the "test bench" but still the software has to be configured for controlling the watch to be functional as the user requirements stated. The design of the hardware and its electric circuits were also extensively delayed and the iteration back to the users for testing the system in reality, with their requirements put into practice, failed. This also had the consequence that the evaluation of the user experience of the system was not conducted.

7.2 Method discussion

There were five future users participating in the workshop and the found requirements can only be completely true for them. The intention with this workshop was to find out ideas from a number of future users to get a notion of what they expected from a system such as SiSSy. As of this, the used method for this thesis has an empirical and qualitative approach, but with no true statistical reliability, i.e. the result can not be generalized for bigger populations. Hence, the intention was not to find out what parents in general would expect. Consequently, there were no specific selections for the participators more than that they should be mixed women and men in spread ages. Of course, they all had to be parents to children in the right age. One question that has to be asked is: Would the result be entirely different if there were five other participants? The answer is yes, it probably would have. But according to Dahlbom [Dahlbom, B. 1997] we are future archeologists discovering future user application from an artefact at hand, in this case the Smart-Its. We cannot predict if the artefact ever will play an important role in our life but neither can the traditional archaeologist. From this, again, the importance of the findings from this work is not the ideas for an application that is supposed to fit every parent; it is the purpose for building an application for the real future world and for real future users.

The scenario strip that is described in 5.1.2 has no previous research method as a foundation and has of course to be questioned for its reliability. It was used for making

the descriptions of SiSSy's capabilities at the workshop easier to understand and the usage was limited to a few minutes. It is likely that this way of illustrating example scenarios does not affect these findings. However, the experience of this strip was that it was useful and it would be interesting to develop this technique further.

7.3 Application discussion

During the work with this thesis, a number of important questions have emerged beside those asked in the introduction. These are related to the SiSSy application itself and the use of it.

7.3.1 Smart-Its on People

When Smart-Its, with its capabilities, is attached to everyday artifacts, entire surroundings can be augmented with computational power, ad-hoc network and context-awareness. A lot of research has been done on how such systems can be value-adding for our daily lives within the research community, as mentioned in section 3. However, the idea with SiSSy proposes an application from a different angle; it integrates ad-hoc mobile sensor nodes with humans. As this was not the initial idea of how Smart-Its were supposed to be used, it has to be questioned if augmenting humans with context-awareness in fact can be value-adding for the user? Within the Smart-Its project the SiSSy is the only project beside the A-life, which deals with tagging humans with context-awareness for safety reasons. It may seem futile as the Smart-Its technology does not have the same abilities as the human brain's flexibility and its ability to interpret what is perceived. How is it possible for a Smart-It to be of any use for such applications? Concerning A-life, the idea is to help rescuing people buried under the snow unable to move or unconscious, Smart-Its devices do not interfere in the domain for human perception, but rather augments it. For SiSSy, it is a different case but as the participants of the workshop stated a similar response: SiSSy should be used as a complement, to minimize the effect of human mistakes and nothing else because it can

never be a substitution. Nevertheless, this demonstrates how enabling technology can be used for purposes not intended.

7.3.2 Immoral aspects

There might also be immoral aspects of this system such as the ethical dilemmas with supervision in a bigger perspective. What can this technology research in the long term create? Of course, the worst scenario is that it can lead to exploitation of technology and be intensively misused for privacy intrusions. This is however criticism to the whole idea of the ubiquitous computing future. Perhaps it must be a trade-off between how much we have to sacrifice in priority and how much we have to gain in security and ease of living. Further SiSSy is something of a hypothetical design test case, making the goal of using a functional prototype on real children in real situations questionable. The reason for this is that children are not something to which an application with highly unpredictable use situations and need for robust implementation, is tested on. What are the implications of such a surveillance system? It is important to note that there have been just a few use applications with the Smart-Its platform, and it is important to do research exploring what the use of the technology in various situations would imply. Simply putting the idea of Smart-Its and their applications to the test with real problems. Maybe SiSSy is not the ideal applications for these worldly experiments but important issue arose from designing it. The main contribution of this thesis to the ubiquitous computing research community seems to be the evaluation of the workshop with the parents and their requirements that shows that there is still a lot of research ahead of us. For example to reliably detect traffic is a huge task.

Due to the workshop participators' response there can also be presumed, without any statistical evidence though, that fully functional applications similar to these might find a way to consumers in the future.

7.3.3 Location Awareness

Using Smart-Its for an application such as SiSSy was criticized at the workshop as it can not provide any absolute location awareness similar to a GPS function. Other spontaneous reactions on SiSSy have been the same. The most urgent answer parents need when a child is missing is “*where*” she/he is to be found. The Smart-Its functionality would then have to be improved with a system as the GPS. This is of course possible but not within the frames of this work. However, the idea with the SiSSy is to try out this application without any required transmitting infrastructure or satellites with just the Smart-Its ability to sense the context, with only the existing sensors. There is a need for questioning if Smart-Its is the right design material for this type application or we should think of it as something for artifacts alone. The use of beacons might partly correspond to this added requirement. But it is a hypothetical idea and would only work if it is possible to create a positioning method between beacons within a certain area.

7.4 Answers for the question asked

The first question for framing this thesis was:

What kind of functionalities would be helpful for parents using such a device as the Smart-Its for monitoring their children?

To get an answer for this there were two additional questions asked at the workshop. For the workshop, the initial question was somewhat rephrased: What functionalities are needed for a Smart-Its system as SiSSy to work properly? The answers for this question were explicit and are the user requirements for the SiSSy application: SiSSy has to sense danger arising and warn before anything has happened. SiSSy must be very reliable to have parents’ complete trust. SiSSy should be able to sense moisture, altitude differences and ability to sense whether the child is near traffic or not. The behavior of SiSSy should be easy to modify. Smart-Its should also be used for tagging the surroundings, used as beacons. There were also arguments for making

SiSSy absolute position aware (unachievable). A wristwatch-like device for the parents should be used, with a vibrator alarm with preferably text messages for the notifications. The SiSSy child device should be attached properly on the child's belt and must be silent.

Additionally, to not only gather functional requirements but also requirements concerning user experience another question was also asked at the workshop: How do you think a potential user would experience a system as SiSSy? This question gave answers of more of an implicit character. For example, the SiSSy would only be experienced as something safe and necessary if the user requirements would be accomplished.

The second question was:

Is it possible to design SiSSy with current Smart-Its technology or should we look at this idea as an experimental design within this area?

This question is related to the implementation phase of this work. Since there was no implementation, there was no answer either.

7.5 Future work

My work will progress in order to satisfy the user requirements as far as it is technically possible using the current Smart-Its platform (making absolute positioning unachievable). The physical characteristics of SiSSy will have its existing shape. The children device will be attachable to a child's belt. In addition, several stand-alone devices will be implemented to be used as beacons. SiSSy's behavior will adapt to the situation and decrease or increase the broadcast radius whether the situation is dangerous or not (as one of the requirements for initiating an alarm is the loss of contact between the devices). The system will also be able to route information through intermediate devices to make the functionality more flexible. The same parents who took part in the above-described workshop will evaluate the first SiSSy ready for use. The test will be carried out in a playground similar to what the workshop map represented.

There can be a discussion of other applications that can be derived from SiSSy as well. The idea of tagging people could also be applied for system caring of the aged in our society. We are living in a world where the elderly part of the population is growing much more compared to other parts. This populace needs to be taken care of in the near future and maybe the ideas coming from the fields of ubiquitous computing, such as the SiSSy, can be used as assets for this caring. Another idea, for more leisure activities, is to create games played in the real world. For example, it would be an interesting if the properties of a functional SiSSy were combined with the application Unmasking Mister X [Antifakos, S. and Schiele, B. 2002], as a platform for game developing.

8 Conclusion

This thesis investigates the idea of an application for helping parents supervising their children. The main question for the work is what kind of functionalities would be helpful for parents using a device based on the Smart-Its platform for monitoring their children? A workshop was arranged with participating parents and the result from this is the user requirements for SiSSy, the Smart-Its child Surveillance System application. The parents had three main requirements. First, of most importance is that SiSSy has to be completely reliable for it to help parents (and personnel working with children). Other requirements are that complex contexts should be detected and understood by the combination of different sensors and appropriate algorithms, and the system should determine whether it is dangerous for children or not.

The implementation of the SiSSy was not accomplished due to some problem during the work of this thesis. However, interesting findings have been made and SiSSy has demonstrated a complex application based on ad-hoc networking and real-time information from distributed and mobile devices. Because of the inherent complexity of the problem, it is most likely that SiSSy will primarily be an experiment to explore the Smart-Its concept and bring up important questions for the use of Smart-Its in a wider sense.

9 References

9.1 Books

Hewett, T. Baecker, R. Card, S. Carey, .T Gasen, J. Mantei, M. Perlman, G.

Strong, G. and Verplank, W. (1996) *ACM SIGCHI Curricula for Human-Computer Interaction*. [Web document], http://sigchi.org/cdg/cdg2.html#2_1 (20 Oct, 2002)

Löwgren, J. and Stoltermann, E. (1998) *Design av informationsteknik*, Studentlitteratur.

Preece, J. (1994) *Human Computer Interaction*, Addison-Wesley.

Sommerville, I. (2001) *Software Engineering*, Addison-Wesley.

9.2 Articles

Abowd, G. and Mynatt, E. (2000) *Charting Past, Present and Future Researching Ubiquitous Computing*, ACM Press, vol 7(1) 2000.

Antifakos, S. and Schiele, B. (2002) *Unmasking Mister X*, Project presentation at the *Disappearing Computer Jamboree*, Gothenburg, 30 Sept.-1 Oct. 2002.

Bellotti, V. and Bly, S. (1996) *Walking Away from the Desktop Computer*, ACM Press USA, Series Proceeding Article Year of Publication.

Dahlbom, B. (1997) *Going to the Future*, in Berleur and Whitehouse (Eds), *An Ethical Global Information Society: Culture and Democracy Revisited*, London, Chapman & Hall.

Dahlbom, B (1999) *The New Informatics*, Scandinavian Journal of Information Systems, vol 8(2) 1997. Reprinted in F. Ljungberg (ed.), *Informatics in the Next Millennium*, Lund, Studentlitteratur.

Dahlbom, B. and Ljungberg, F. (1999) *Mobile Informatics*, Scandinavian Journal of Information Systems, vol 10(1&2) 1999.

Dey, A. (2001) *Understanding and using context*, Personal Ubi Comp vol 5(1), 2001.

Gellersen, H-W. Schmidt, A. and Beigl, M. (2002) *Multi-sensor Context awareness in mobile devices and smart artifacts*, Journal on Mobile Networks and Applications (MONET), Oct 2002. [Web document]
<http://www.comp.lancs.ac.uk/~hwg/publ/monet.pdf>, (20 Oct, 2002).

Hansson, R. and Ljungstrand, P. (2002) *The Reminder Bracelet: Subtle Notification Cues for Mobile Devices*, Extended Abstracts of CHI 2000, ACM Press. [Web document] <http://www.viktoria.se/groups/play/publications/2000/rembrace.pdf>, (20 Oct, 2002).

Holmquist, L-E. Falk, J. and Wigström, J. (1998) *The Hummingbird: Mobile Support for Group Awareness*, ACM CSCW '98, Seattle, USA. [Web document]
<http://www.viktoria.se/publications/98/VRR-98-30.pdf>, (20 Oct, 2002)

Holmquist, L-E. Mattern, F. Schiele, B. Alahuhta, P. Beigl, M. and Gellersen, H-W. (2001) *Smart-Its Friends*, *Proceedings of UbiComp 2001*, Atlanta, USA. [Web document] <http://www.smart-its.org/publication/smart-its-friends.ubicomp2001.pdf>, (20 Oct, 2002)

Holmquist, L-E. and Mazé, R. (2002) *Smart-Its Scenarios: Methods and Results*, IST-2000-25428 project Deliverable no. 4. [Web document]
http://www.viktoria.informatik.gu.se/groups/play/projects/smart-its/Smartits_D4_210102.pdf, (20 Oct, 2002)

- Iacucci, G. Kuutti, K. and Ranta, M. (2000)** *On the Move with a Magic Thing Role Playing in Concept, Design of Mobile Services and Devices*, Proceeding of COOP'2000, Designing Cooperative Systems Conference. [Web document]
<http://www.cs.hut.fi/~pmrg/publications/2000/p193-iacucci.pdf>, (20 Oct, 2002)
- Jernström, H. (2002)** *SiSSy – Smart-Its child Surveillance System*, Adjunct Proceedings of UbiComp2002, Göteborg 2002.
- Kristoffersen, S. and Ljungberg, F. (1998)** *Representing Modalities in Mobile Computing. Interactive Applications of Mobile Computing*, IMC98, Online proceedings. [Web document]
<http://www.rostock.igd.fhg.de/veranstaltungen/workshops/imc98/Proceedings/imc98-SessionAS1-1.pdf>, (20 Oct, 2002).
- Michahelles, F. Ahonen, T. and Schiele, B. (2002)** *Smart-Its for improving avalanche rescue*, Project presentation at the Disappearing Computer Jamboree, Gothenburg, 30 Sept.-1 Oct. 2002.
- Mazé, R. Ljungstrand, P. Nilsson, M. Rydenhag, T. Gaye, L. and Holmquist, L-E. (2002)** *Smart-Its go to Dinner*, Project presentation at the Disappearing Computer Jamboree, Gothenburg, 30 Sept.-1 Oct. 2002.
- Myers, B. (1998)** *A brief history of human computer interaction technology*, ACM Interactions, vol 5, 1998. [Web document] <http://www-2.cs.cmu.edu/~amulet/papers/uihistory.tr.html>, (20 Oct, 2002)
- Want, R. Hopper, A. Falcao, V. and Gibbons, J. (1992)** *The active badge location system*, ACM Transactions on Information Systems, 10(1), 1992. [Web document]
<http://sandbox.xerox.com/want/papers/ab-tois-jan92.pdf>, (20 Oct, 2002)

Weiser, M. (1991) *The computer for the 21st century*, Scientific American, 265(3) 1991.
[Web document] <http://www.ubiq.com/hypertext/weiser/SciAmDraft3.html>, (20 Oct, 2002)

Weiser, M. (1993) *Some computer science issues in ubiquitous computing*, CACM, In Special Issue, Computer-Augmented Environments, 1993. [Web document]
<http://www.ubiq.com/hypertext/weiser/UbiCACM.html>, (20 Oct, 2002)

Weiser, M. (1994) *The world is not a desktop*, Perspectives article for ACM Interactions, 1994, [web document]
<http://www.ubiq.com/hypertext/weiser/ACMInteractions2.html> (20 Oct, 2002)

Weiser, M. and Brown, J. (1996) *Designing calm technology*, PowerGrid Journal, v 1.01, 1996. [Web document] <http://www.ubiq.com/weiser/calmtech/calmtech.htm>, (20 Oct, 2002)

9.3 Internet pages

DC - Disappearing Computer homepage: <http://www.disappearing-computer.net/>, (20 Oct, 2002).

Smart-Its - Smart-Its homepage: <http://www.smart-its.org/>, (20 Oct, 2002).

PLAY - Smart-Its project homepage at PLAY:
<http://www.viktoria.informatik.gu.se/groups/play/projects/smart-its/>, (20 Oct, 2002).

TecO - Smart-Its hardware and software descriptions at: <http://smart-its.teco.edu/release/>, (20 Oct, 2002).

UbiComp - UbiComp 2002 Conference homepage: <http://www.viktoria.se/ubicomp/>, (20 Oct, 2002).

Usor - *Usor - A collection of user-oriented methods:*

http://sunrize.nada.kth.se/usor/jml.cgi/User/user_participation.jml?graphics=true, (20
Oct, 2002).