

MAKING UBICOMP ACCEPTABLE IN THE HOME

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ABSTRACT

This thesis is concerned with the uses of ubiquitous computing (ubicomp) technologies in everyday domestic settings. In contrast to goal-oriented technology adoption (e.g. in the workplace), the integration of pervasive technology in the home faces not only social but also physical and technical constraints. We propose a design framework for the introduction of ubicomp technology into today's homes that, firstly, considers a holistic approach to integrating pervasive technology; secondly, takes into account social factors and domestic activity when defining the nature of the system's interaction; and thirdly, allows the user to adapt the system's interaction and collaboration.

Most of the work to date on domestic ubicomp takes the customization of domestic spaces for granted, presuming that the integration of sensing technologies can be accomplished to any required degree and usually assuming that context-aware systems have to be proactive, limiting users to the role of consumers of the system's actions rather than allowing them a more participative or cooperative role.

We have applied our framework to design a domestic ubicomp system to support parents with childcare in the home. The "Context-Aware Room" and the "The Parent-Child Companion Tool" prototypes are built to take account of the interaction between the social and physical and the social and digital contexts in order to address issues of integration of sensing technology, socially respectful collaboration and system adaptation.

Two studies explore the potential social acceptance of the PChCT. The panel study considers parents' overall perceptions of whether these kinds of ubicomp tools might help with parental tasks. The usability study considers the usefulness and usability of the PChCT. The results of the study reflect a positive attitude to the PChCT. Parents liked the collaborative resources and facilities to tailor collaboration. Further work might be done to assess how the system's adaptation might fit within a wider context of user needs. Nevertheless, we argue that the use of our framework can lead to more socially acceptable ubicomp experiences in the home.

CHAPTER I

INTRODUCTION

The evolution of our society and lifestyle seem to be a rich context in which computers might support living spaces. For the home in particular, we have seen how computer-based artefacts such as TV set top boxes, washing machines, wireless devices and microwaves, have been adopted to address group or individual needs and aspirations. Typically, such technologies appear to help people to manage the home. Despite its benefits, however, interaction with this technology demands a great deal of user attention. A user has to instruct the artefact explicitly in what task has to be done and how. The new era of innovative technology suggests that artefacts can be smart enough to sense users' intentions and to anticipate services that could meet their needs. Visions of the near future have *intelligent* networked devices that express the message "Don't worry, we know what you mean, we can do it for you". A smart-home scenario may have a plethora of pervasive and ubiquitous technology which is alert to users' activities, and which can potentially improve living spaces not only through automation of appliances but also through awareness of the well-being of family members. For instance, context-aware services could support aging people in the home, or support parents with housework and facilitate their childcare activities. This is the vision of context-aware computing.

Although this vision for smart living spaces and novel human computer interaction might be seen as promising, context-aware experiences in the home to date show a less optimistic perspective. There are two main problems facing context-aware designs: the collection of information about the user's activities and the processing of these contexts to define the system's awareness. The latter typically depends on how well the sensing technology is integrated within the domestic setting. The incorporation of pervasive technology to collect context information from the user's behaviour is typically constrained by physical and social issues.

This thesis is concerned with designing a novel domestic ubicomp (context aware) system that specifically considers the facilities and constraints of today's homes. We propose a design framework that takes into account the user's broader context

together with the design and operation of the ubicomp system. In this framework, the user's context specifically includes the home's built environment and the social interactions that shape and are shaped by these spaces. That is, contrary to what is often assumed, our approach is sensitive to the potential obtrusiveness of integrating pervasive technology within the home. The social context is also borne in mind when defining facilities for collaboration and interaction. We believe that accounting for these social aspects of domestic life will help to design socially acceptable ubicomp experiences for domestic settings.

Before describing the work carried out, we briefly describe the importance of the technology, the built environment and the social interactions that might influence the acceptance of computer-based support within the home. Following this, we offer our preliminary experience of building a context-aware artefact which helps to illustrate the importance of the aforementioned design elements and that fuelled our interest in using a more socially-aware approach to the design of domestic context-aware systems.

1.1 Issues relating to context-aware ubicomp designs for today's homes

We already mentioned that context-aware systems depend on pervading the home with ubicomp technology, and we pointed out that there are two contexts – physical and social – that are of paramount importance when moving such technology into the home. We introduce below some of the social and physical factors that can limit the potential acceptance and adoption of pervasive technology in the home.

1.1.1 The social context

In 1996 a longitudinal study carried out by Venkatesh [Venkatesh, '96] contrasted the evolution of information and telecommunication technologies and their interactions within the everyday life of the household. It was realized that the adoption of technology within the home is typically associated with the benefits it might offer to the social organization of the home and the ways in which family members conduct their lives; i.e. technology can modify not only the attendance to household work but also people's lifestyles. For instance, washing and vacuum machines seemed to be adopted because they empower housework, but also because these technologies allow people attend to more than one task at the same time. It is

clear, then, that the utility of technology must be visible if it is expected to be accepted and adopted within the home. That is, “the design of technology for domestic environments should be done with the knowledge and understanding of the family members’ activity” [Hughes et al, ‘98].

For context-aware designs this is challenging. The collection of context activity to represent user’s behaviour and feelings might imply the use of a great deal of technology, and although we could augment any available artefact with technology within the home its utility might not be clearly seen by some users. For example, consider the augmented fridge which is able to identify and report when there is a lack of food; can we assume that every householder is interested in being told by a fridge what to include in their shopping list? Nevertheless, if we presume the utility of the *smart* fridge, as for other *intelligent* artefacts, what degree of sensing technologies might be sufficient for designing these kinds of context-aware artefacts? There seems to be no simple answer, because we must know what function end-users would like to see from a particular *smart* artefact. However, we do know that richer context-gathering should lead to a better understanding of users’ activity, and better representation of user activity should lead to richer support for users. Therefore, in the final analysis it seems to be the user who should decide how relevant the offered support is, according to their current circumstances [Ouslavirta, ‘04].

1.1.2 The physical context

As we recognized from the previous section, the accommodation of pervasive technology into domestic settings cannot be taken for granted. Today’s homes might not have the flexible infrastructure to integrate the technology that context-aware ubicomp designs might need [Rodden et al, ‘04], while the dynamics of space use and the mobility of artefacts in the home could also affect the accommodation of ubicomp technology. For instance, the room’s “stuff” (furniture, etc.) is re-arranged from time to time as the user wishes, and we could imagine resulting changes in sensor orientation, which could affect the system’s sensing of activity. Home furniture or artefacts can disappear at the user’s convenience; the replacement of a microwave or a TV set, are two such examples. These dynamics of domestic life might depend on, for instance, usability or aesthetic issues.

Another level of aesthetic issues can arise from specific installation requirements. For instance, consider the installation of a CCTV system to help with the home's security; where should this technology be placed? Should it be installed in the ceiling or in a corner of the room? Should we drill into the wall? Is it wired or wireless? Is it in tune with the décor of the room?

We can summarize that physical and social contexts are interrelated and play an important role within the design and realization of ubicomp systems within the home. To explore their importance, therefore, we built a small context-aware scenario, the context-aware cupboard prototype, which allowed us to understand in greater depth the interaction of the physical and social contexts with sensing technology. The next section briefly describes our experience with the context-aware cupboard prototype, but more detail is given in appendix A.

1.2 Understanding social factors in order to design domestic ubicomp systems

In an effort to achieve a better understanding of the technical, physical and social interactions and their effects on the gathering of context, and hence on the awareness of a ubicomp system, we built the context-aware cupboard prototype.

The context-aware prototype aimed to simulate a scenario in which an augmented cupboard helps parents to provide safe spaces and artefacts for children. In particular, the cupboard is able to recognize the person using it, and with that information the artefact decides whether or not to allow access to its contents. That is, the system is aware of the child's proximity to the cupboard and will allow its use only if permission is granted by the parent.

The motivation underlying this “hazard-free” scenario for the child-cupboard interaction is established as follows:

Within cupboards it is possible to find chemicals, dishes, drinks, utensils, and so on. With their natural curiosity, young children often open cupboard doors to explore. If the cupboard is aware of the child's attempts to interact, it could inform the parent about this activity, thereby assisting with the supervision of the child.

A small cupboard was augmented with phidget technology (see figure 1.1) to create the cupboard prototype. A servomotor, an RFID reader, a light sensor and a touch sensor were accommodated within the cupboard. With this technology we can control the door, know its state (closed/open) and get some context such as the user's ID (by the RFID tag that is worn). We also attached RFID tags to some containers simulating cleaning material.

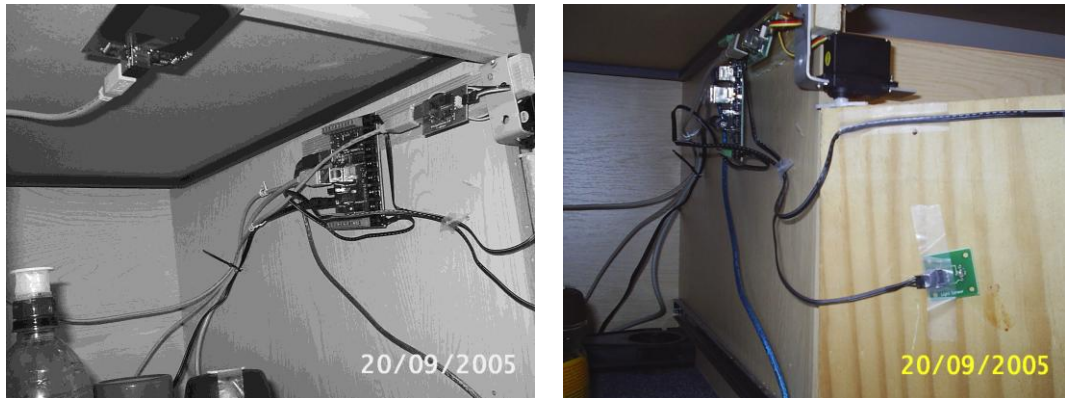


Figure 1.1 The aware cupboard prototype augmented with phidget technology

We envisaged three levels of awareness from the cupboard prototype. First, a security level should guarantee that the door is closed unless interaction is allowed. Second, the cupboard should be aware of situations in which the parent and the child are together and close to the cupboard. In this situation we believed that the cupboard should respect parental supervision and potentially allow the child to interact with the artefact. The top level of awareness was thought of as a continuous learning process for the context-aware cupboard: its “*smart*” level. For instance, if the cupboard has learnt under which circumstances the parent grants permission, then the cupboard might be smart enough to decide whether to open its door or not to the child.

A brief description of how the cupboard might be aware of the child's activities is given below (see appendix A for more details):

When the RFID reader detects the child's presence, via the tag being worn by the child, the system checks if the door is closed. To do this, the status of the light sensor is used. As well as reporting the child's activity to the parent, the system is aware of any commands coming from the parent's user-interface, in case permission for interacting with the artefact is granted. If this is not true then the

door is kept locked (open otherwise). Any activity around the door of the cupboard is recorded to a file.

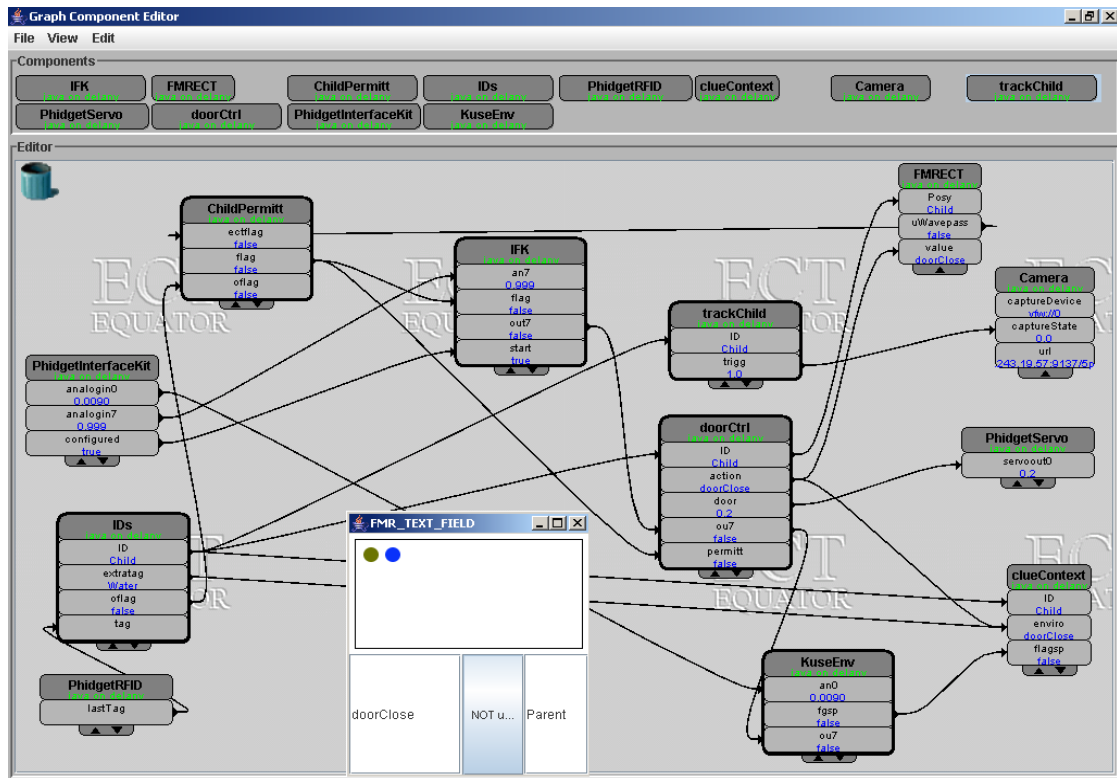


Figure 1.2 ECT Graph Editor and the software components of the cupboard prototype

To interact with the sensing layer we use the Equip Component Tool (ECT) [Greenhalgh et al, '04], figure 1.2. There we observe the interconnection of the components of the prototype system to implement the cupboard's awareness. The software components with a bold square are used to implement some rule-based processing for the context-aware cupboard whereas the remainder are the interfaces to the sensing devices. In the bottom area there is the UI that offers information about the state of the door and the person currently identified, and the button in the middle can be used to open or close the door of the cupboard.

We are using this overview of the implementation of the context-aware cupboard prototype to point out the importance of technical, physical and social considerations while designing a context-aware system, some of which are outlined next.

1.2.1 The lessons

Accommodation of technology – augmenting artefacts or appliances with ubicomp technology is challenging. The cupboard prototype taught us that physical concerns will arise when looking for home spaces in which to site technology. The

incorporation of technology can demand physical resources which are not always available, or which require the alteration or modification of the artefact itself. For instance, to accommodate the servomotor within the prototype the original cabinet door was removed, and nails and Velcro were used to fix the motor firmly. Moreover, because most of this kind of furniture does not provide access to an electrical source, a new cabling path was necessary to power the technology.

Social intrusiveness – there are two dimensions of intrusiveness found in our aware cupboard prototype. The most notable is that a person needs to wear an RFID tag. The approach of tagging people might be seen to be highly intrusive and, unless the tag is attached to their skin, we cannot guarantee that people will wear it all of the time. Thus, the selection of technology should consider how it impacts on the human and social context.

The second dimension regards the mechanisms available to users for interaction. The use of some technologies to monitor the user's activity might require an explicit user interaction. For instance, consider a scenario in which RFID is used to gather information on how many times a day a person enters the kitchen. To ensure that each entry to the kitchen is registered we may need to ask the user to touch the door frame each time – the RFID reader, to be precise. It seems therefore that the use of this kind of technology could affect people's activities.

Context-aware artefacts – we have already stated that the awareness of a system relies upon the available context information and that the monitoring of activity might depend on how relevant the user perceives the ubicomp service to be. This returns us to the initial point of how users might help to decide awareness requirements for domestic ubicomp designs. For instance, in the particular case of caring for young children, does our cupboard prototype offer the level of awareness that parents need in order to monitor their child's safety? We should avoid making assumptions about what technology can do for users and what users might need from technology [Venkatesh, '96].

There is another social issue present, related to the specific collaboration with the parent. For instance, we could ask whether the context-aware cupboard should

interrupt the parent's activities. What type of information should be delivered? Is there something happening that might put the child at risk and that requires the parent's attention? Could the parent control this situation remotely? Finally, has the context-aware cupboard enough technical resources to support parental tasks? Thus, as previously stated, if we are able to identify more clearly what users might need, then we could determine the awareness required by the system.

To complement this formative knowledge and understanding of potential issues that might arise when designing context-aware systems for the home, we decided to get an initial view of parents' perceptions of using computer-based technology to help them with some of their parental activities.

What might parents need?

After exploring our context-aware scenario, we decided to find out what people might think about using technology to help them with some of their parental tasks. Three parents were asked to answer a questionnaire soliciting information about how parents manage household work and childcare. In particular, we were interested in parents' perception of the extent to which technology could help them to supervise children's activities. Here we present summaries and some excerpts that complement our experiences with the context-aware cupboard prototype:

Mother 1 – student with a 9-month child:

Household work is done in spare time and mostly caring for the child at the same time. While attending to housework the child is kept in a secure area, e.g. the highchair, and entertained. When undertaking cleaning tasks that include the use of chemicals, the child is kept at a distance but under supervision. When cooking, the child is under constant supervision and kept away from the preparation area. The use of technology for supervising the child's whereabouts might be welcomed, but, its utility is perceived only for the early development years: "Visual child monitoring could be helpful when you have to leave your child, for example, to answer the door or go to the toilet."

Mother 2 – half-time paid job with an 11-months old child:

Cleaning tasks are left mainly for weekends when there is someone who can look after the child while doing household work. There is a complete social awareness of the child's activities – “need to make sure the child is not touching/smelling the cleaning chemicals, or away from anything hot and sharp”. However, it is argued that the child at this stage is young and with a low level of activity and, therefore, there seems to be a low appreciation of using technology for monitoring the environment and use of home spaces: “Impractical, there should always be parental supervision for young children around the home”... “I would prefer to have technology that did the cleaning and chores for me.”

Mother 3 – half-time paid job with a child 4 years and 3 months old:

There is a flexible policy for doing household tasks. At this stage of development the child is allowed to join with the mother, for example, in the cleaning tasks. When helping, the child is often warned about potential dangers that can be faced with cleaning or cooking activities. A context-aware system might have been accepted when the child was younger but at this time her privacy is considered valuable: “This appears to remove the parents from interacting with their child at a very vital stage in the early life”... “Parents do need to assess and minimise risks to the child even so this does not guarantee an accident-free situation.”

From the perceptions of these parents, we have identified different considerations which affect how the usefulness and usability of ubicomp technology might be perceived. One element is related to the child's development. We believe, therefore, that a context-aware system design cannot be uniform; but on the contrary, must be designed flexible to allow parents to adapt its behaviour. Another related element is associated with the level of the system's proactiveness. Parents seem to argue that some help from technology might be accepted but they will not accept technology that attempts to undermine their own parental role. This latter reflection makes us to think not only about the degree to which technology should be used to augment artefacts, appliances, home spaces and so on, but also about the level of context-aware collaboration that parents might accept.

In summary, we seek to highlight the importance of technical, physical and social considerations within the design of context-aware ubicomp experiences, recognizing that the acceptance of ubicomp systems within the home might be constrained according to the circumstances of each particular household and its members: “Computing is not only looking for a physical space but also crossing social and cultural boundaries.” [Sengers et al, ‘04]

1.3 Thesis goals

The formative experience gained with the implementation of the context-aware cupboard prototype, and soliciting initial views from parents helps to establish two main goals for this work: -

To give a formal account of the social context to inform the collection of information about domestic activities through sensing technology and to allow the system to be adapted to current users’ preferences and behaviour.

Followed by: -

To implement this framework in order to evaluate whether such a design is perceived as socially respectful of the living space and whether users feel comfortable with their interaction with such a ubicomp system to adapt levels of collaboration.

1.4 Thesis Contributions

The contributions of this thesis are:

- *A framework for designing socially acceptable ubicomp experiences in today’s homes.* This thesis proposes a framework that specifically takes into account the convergence of the social and physical contexts when moving pervasive technology into the home, and the social and digital contexts when defining facilities for collaboration and interaction. That is, the user is considered in the accommodation of sensing technology to collect context and also in the definition of the system’s interaction.
- *Design and implementation of a ubicomp prototype to sense users’ activities.* We design a context-aware room prototype that demonstrates a less intrusive approach to gathering information about some everyday parental activities.

The integration of technology within the room prototype takes into account social concerns such as: the felt needs for parental support, the facilities within the built environment and the degree of intrusiveness within the living space. This approach allows designers to explore realistic context-aware services using the available context information.

- *Design and implementation of a ubicomp UI that mediates collaboration from and interaction with the aware room prototype.* This thesis uses a socially respectful approach to support householders. The Parent-Child Companion Tool, PChCT, takes into account parents activities and attempts to respect this social context when conveying information. In addition, the PChCT tool considers the variability of parental needs and allows parents to adapt the system's collaboration to their current circumstances.
- *A qualitative and quantitative study that explores the social acceptance of this kind of ubicomp support.* This thesis presents a user study carried out in a nursery setting to gather feelings and attitudes from 20 parents. The survey uses a modified group-administered questionnaire to elicit information about general social perceptions and awareness of technology-based support for the home. This also allows the identification of social issues across a range of different parental situations and the possible degree of acceptance of this type of ubicomp technology.
- *A usability study that explores the acceptance of this type of parental support and which informs future developments.* Three parents were given experience of the PChCT in their homes, and the results from these studies help with the identification of individual issues in the acceptance and adoption of this type of ubicomp tool. From their experience parents assess the collaborative and interactive facilities offered by the PChCT.

1.5 Thesis Outline

Chapter two reviews research related to the work carried out in this thesis. This includes a discussion of how diverse context-aware experiences proposed for the

home by others in the current literature manage the associated technical, physical and social issues, and the kinds of support being offered to occupants.

Chapter three introduces a conceptual framework to support the design of context-aware systems in today's homes. We describe a holistic approach which considers the convergence of technical, physical and social contexts at the early stages of the design process. This holistic approach can then help to identify realistic possibilities for context gathering and scope the system's interaction. The framework also considers mechanisms for the adaptation of the system's collaboration in order to reduce its obtrusiveness. Overall, we believe that this approach might help to design more socially acceptable ubicomp experiences for domestic settings.

Chapter four presents the Context Aware Room (CARoom) and the Parent-Child Companion Tool (PChCT) prototypes. These are the results of employing the framework to implement a context-aware experience within a real home. The context-aware room prototype is used to collect activity data from three parent-child activities. This activity is then processed to drive the collaborative and interactive facilities of the PChCT. This tool is used by parents to receive information from, and to interact with, the CARoom.

Chapter five describes the methodology used to explore the social acceptance of the PChCT ubicomp tool that aims to support parents in the home. Similarly to the "Technology Probes" approach [Hutchinson et al, '03] we make use of different evaluation methods – technology-probe-like prototype, field-testing, video-demonstration, surveys and interviews – to assess and understand parents' appreciation of the usefulness of ubicomp technology. In particular we have used a questionnaire-based panel survey, and a hands-on usability study. The panel survey is a single session study in which the technology is introduced with a video demonstration; this demonstrates "how to use" and "what to expect from" the PChCT; then a questionnaire elicits users' attitudes to the PChCT. The usability study comprises two sessions. In the first session parents are introduced to the activity-aware room; within the same session we collected data from the child's activity. Within the second session parents use and explore the collaborative resources available from the PChCT, and a semi-structured interview helps to

identify parents' attitudes. The results of these two studies are combined to explore user acceptance and potential opportunities for the improvement of this type of ubicomp tool.

Chapter six assesses the potential for social acceptance of the PChCT tool from the panel group. Results are presented at three levels of users' perception. At the first level, general results reflect the overall perception of parents regarding the use of a ubicomp tool to help them in supervising children's activities. In the second level, results explore variations of parental attitudes with children's ages. Finally, the level three results analyze, from a purely social perspective, the views of the less positive parents about the PChCT.

Chapter seven presents data reflecting the parents' observations and attitudes to the PChCT tool from the usability study. Results are presented in terms of social perception of the usefulness and usability of the PChCT. These acceptability parameters are used to explore individual contexts that might influence the acceptance of the collaborative and interactive facilities available within this tool.

Finally, chapter eight contains a summary and conclusions with suggestions for future work.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The previous chapter introduced some of the physical and social issues that may affect the acceptance of pervasive sensing and thereby the experience of context-aware systems within the home. We briefly reviewed how people seem to adopt technology with regard to its benefits to household management and also how some social aspects of domestic life might constrain the acceptance of unfamiliar technology. We presented our preliminary context-aware prototype and social study which shaped our understanding of the issues that affect context-aware designs and which fuelled our interest in exploring potential ubicomp applications to support everyday activities.

The integration of sensing technology is doubtless one important element of any context-aware design, and for domestic settings in particular this determines the scope of the ubicomp system's capability. This chapter reviews the implementation of some previous context aware experiences, highlighting their aims and discussing issues around the accommodation of pervasive technology. We have grouped these ubicomp experiences into four categories: laboratory-based, which considers work carried out in purpose-built facilities or in homes that have been adapted as live-in laboratories; affective awareness, which considers work focused on supporting communication between family members; daily activity monitoring, which includes work with various technology-based approaches to gathering user behaviour data; and finally user-ubicomp interactions, which considers work focused on mediating interactions between users and technology.

The order and diversity of the reviewed literature serves to illustrate how the "awareness" concept has evolved within the context of domestic settings. Further, because it reflects the importance of gaining knowledge and understanding of the behaviours and diversity of householders, it illustrates the different social contexts explored for ubicomp collaboration and social perceptions of context-aware computing support.

In order to introduce formally the importance of these elements in the design of domestic ubicomp systems, we present the “Casablanca” experience [Hindus et al, ‘01] as an initial example. This project uses the media space concept to explore the extent to which current home technologies influence household communications, and to investigate potential opportunities for designing communication devices that might be needed by users. The intentional presence lamp and the scan board are two of the prototypes which were created to engage people with new forms of communication device. From their experience in developing those artefacts we highlight the presence of technical, physical and social issues.

Firstly, the authors explored needs for communication between householders who live apart. This reflects a research interest in supporting family members with systems that allow them to communicate. We believe that, within the home, this kind of computer collaboration could support awareness between family members.

Secondly, to arrive at the aforementioned prototypes they developed nine pre-prototypes, which included the testing of different kinds of ubicomp technology: laptop computers, audio and video systems, ISDN communication, ambience lamps, and wearable devices among others. These experiences exemplify the importance of selecting the “appropriate” technology for the gathering of information about the environment and user activities within the design process of ubicomp tools for the home.

Thirdly, over fifty ethnographic studies were undertaken to identify and inform designers about the kind of devices and/or services that might meet users’ needs. Some of the issues found within the evaluation of both prototypes relate to the social acceptance of novel technology, the intrusiveness of this technology within “living” spaces and the potential impact on people’s privacy. These three elements should be taken into account in context-aware designs.

From this we recognize the challenge of exploring ubicomp experiences within the home. Technology should be carefully identified, tested and integrated within the physically available building resources. Nevertheless, the utility of such ubicomp

technology must be clear. We start therefore by reviewing previous work bearing in mind these design concerns:

1. The nature of the proposed service offered by each system – this will give information about the social and individual “needs” that might be supported.
2. Integration of technology – to identify the kind of technology and the scale of its integration within the setting. This information might help to identify trends in technology but, in particular, also recognise its current benefits and limitations when considering its integration into everyday settings.
3. Degree of social acceptance – we will highlight user feelings about the proposed ubicomp collaborations.
4. User interaction – when available we will identify whether the system leads collaboration or if the user has a more participative role within the ubicomp system.

2.2 Laboratory-based experiences

In this section we review work that has been carried out either in purpose-built homes or in homes that appear to be treated as live-in laboratories. These experiences are often characterized by the kind and degree of technology used to study and monitor users’ behaviour. These laboratory-based experiences are used as the starting point to discuss physical and social issues as we attempt to project these technology scenarios into realistic homes.

2.2.1 Ambient Intelligence

The concept of Ambient Intelligence [De Ruyter and Arts, ‘04] has been used to explore user-artefact interactions as a means of identifying potential markets for information products. Traditional media artefacts such as TV, video players and Hi-Fi systems are thought to be replaced by virtual devices embedded within intelligent environments. This virtual environment should allow users to interact ubiquitously with, for instance, an ambient display, anywhere. Other levels of this kind of intelligent domestic support might include automation of kitchen activities. For instance, intelligent kitchens might manage the shopping list or use information about available food to formulate possible recipes. The HomeLab, which is the laboratory setting being used as the test bed for some of the ambient intelligence visions, hides cameras and microphones in the false ceiling, conceals cabling in

double floors, and accommodates equipment such as computers in corridors adjacent to the rooms. However, although these could be viewed as interesting future scenarios for domestic human-computer interaction, it seems unlikely that they would be realised in today's homes.

2.2.2 The Aware Home

At the Georgia Institute of Technology a longitudinal study of social interactions with future computing resources is explored in a live-in laboratory, the Aware Home [Essa, '00]. Ubiquitous sensing technology is used to explore smart and aware environments. Audio, video, RFID, ultrasonic, force-sensitive and vibration sensors, and grids of piezoelectric wires and optical fibres are among the technologies used within the Aware Home. These technologies are used to develop ubicomp applications that include videophones, intelligent surveillance and monitoring, speech and gestural interfaces, education and entertainment. The Aware Home is primarily focused on supporting the everyday lives of the elderly. Some of the context information that the study was interested in includes identity, location and activity. For instance, the smart floor uses force-sensitive and vibration sensors to identify and locate a person based on his or her footsteps. The "Frequently Lost Objects" system uses a tagging approach to recognise user-objects interactions and support people in situations where objects are misplaced; this system is seen to empower memory. Although the usefulness of these approaches might be socially accepted, there are physical and social issues that will constrain their implementation in the home setting. We might argue, for example, that today's homes do not have the flexibility to re-design room layouts or to create new spaces to accommodate arbitrary sensing technology such as RFID or ultrasonic-based systems. Furthermore, wearable technology is typically seen as socially intrusive and its use with family members other than (or including) elders might be rejected.

2.2.3 The MAV_Home

The Managing and Adaptive Versatile Home [Cook, '03] explores how environments that are augmented with technology could maximize comfort for inhabitants. On the basis that pervasive computing is becoming part of home settings, this work aims to support householders' lives by automating the home environment, conserving resources and improving safety and security. It is argued that if the MAV_Home can monitor its own "well-being", by, for example requesting maintenance or informing

inhabitants about emergencies, then this indirectly contributes to the elder's well-being, as safety is guaranteed. Pervasive technologies used include devices such as power line control interfaces (X10), stepper motors, reed switches, touch screens and cameras, and low level sensors to monitor light, humidity, temperature, smoke, gas and motion. Each of the six rooms within the MAV_Home hosts 7 X10 devices, an average of 12 environmental sensors plus some stepper motors. The MAV_Home makes use of interesting technology, however, besides the inherent physical issues, there were also some problems with the systems' reliability:

"Failures occurred to some minor sensor noise causing the patterns of user's activity to appear different from the system training data."

Thus, designers should be extremely careful with the selection of candidate technology, and moreover, account for environmental factors that might affect its performance: novel technology that seeks to be accepted in the home should aspire to be "error-free", otherwise it may be refused.

From these examples we realize that great benefits may be obtained when using purpose-built environments. The diversity and scale of sensing technology that can be accommodated allows designers to collect rich context information and therefore define different levels of system awareness. There are few physical and social constraints. Participants know in advance the type of system with which they will be involved, including the technologies used to monitor and track their activities. This prior agreement might include dealing with some privacy concerns.

Unfortunately, the approach of using such "controlled" scenarios to obtain user context information might be difficult to reproduce in real homes:

"Domestic activities mean that people can get out the door, feed themselves, put the children to bed, and so on, without eternally having to take pause and invent sequences of action anew or open up their every facet for inspection or challenge or to constantly have to account for what they are doing with explanations or rationales." [Tolmie et al, '02]

Unlike the previous examples, the following experiences are more focused on exploring a particular collaborative approach. Although these scenarios are less “controlled” we will see that there still are some physical and social issues.

2.2.4 *Map of our lives*

Map of Our Lives [Aipperspach et al, ‘05] is used to sense people and objects in the home. This study explores whether the use of mobile technology might be linked to the householder’s everyday activities. The location and tracking of portable computing devices is used as the means to gather context information such as the use of the spaces within the home and the practice of concurrent activities such as watching TV and using a laptop. Tags are worn by users and also attached to artefacts. The proximity or closeness between tags is used to identify users’ interactions with artefacts. Additional context information such as log files and the on or off state of artefacts are used to discern parallel activities. For instance, if a user is located on the couch and the computer log shows that it was used at the same time as the TV was on, the system might infer that the user was working with the computer concurrently with watching a TV program. Technology used in this work includes the Ubisense positioning system, current sensors, X10 devices and the user’s laptop. Thus we might argue that despite the benefits of using a high precision system for tracking and location, the accommodation of this technology within real homes might be quite intrusive because of the physical requirements for its installation. Also, we note two social assumptions: the user’s willingness to wear a tag, and the consideration of the home as an extension of the workplace. We believe that both of these assumptions might constrain the application of this approach.

2.2.5 *AMIGO*

AMIGO [Jouve et al, ‘07] is a software architecture proposed to design monitoring applications. The system is intended to facilitate the development of context-aware experiences to support interpersonal awareness for elders or children. A laboratory office was adapted to accommodate a Ubisense system. Other technologies included sound, video, mobile devices and UPnP-based devices. The system explores collaborative approaches to raising awareness of family members. For example, if the system detects a safety issue it uses different mechanisms such as blinking lights, text-based messages or siren-like sounds to alert the caregiver. The first element to realize here is that some of these technologies require physical spaces that might not

be available in today's homes. Second, as in the previous study [Aipperspach et al, '05], it is taken for granted that wearable technology will be accepted by householders. Thus, although these assumptions help AMIGO to convey awareness, there may be problems with the social acceptance of this type of user-ubicom interaction: tagging people and aesthetics are two significant issues when considering living spaces.

2.2.6 H3 robot

Perhaps the ultimate expression of a smart home is a robotic home, a setting in which robot systems are ready to act on behalf of humans. It is argued that the H3 robot [Simo et al, '06] could address childcare tasks in the home. The robot indirectly deals with children's activities when they move towards objects that might be a potential risk or a probable cause of an accident. In this type of scenario the robot could choose between two different forms of intervention. One of these might be to place itself between the potential hazard and the child. The second might be to distract the child so that the child's interest in the artefact subsides. To that end, the robot could use its multimedia capabilities. For example, the robot can play some music or invite a child to play a videogame. It can also reproduce a parent's advice. Some of the social issues found in this study include the child's period of adjustment to a robotized environment.

“Her neophobia transition period was much longer and more dramatic... she was not able to stay alone with the robot....”

Another potential issue is associated with the ultrasonic system that is used for location and tracking because this type of sensing system typically requires special care in its installation.

Laboratory-based settings have been valuable to explore diverse technical and social issues and interactions. This approach allows designers to investigate possible future human-computer interactions. However, these “controlled” environments often present a “rosy” picture of ubicom collaborations. We have seen that, as we move out of a laboratory, technical and social issues become more pronounced, and perhaps more problematic as is exemplified in the following sections.

2.3 Affective awareness

This section reviews work that is concerned with support for interpersonal awareness between family members. In contrast to the previous section, here we find only a low level of sensing technology, but a high level of interest in supporting novel means of communication for distant householders. The desktop-like approaches of most of these experiences provide good examples of physical and aesthetic issues, highlighted in the photographs that follow.

2.3.1 *Gustbowl*

This is an artefact designed to support family members who live apart. Interactions with the Gustbowl [Keller et al, '04] help families to keep in touch and to feel they are close in space. In particular, the artefact serves as an awareness medium to inform a mother about some of her child's activities when he or she is living in a distant dwelling. For example, when the child comes home and puts some personal things in the Gustbowl the parent receives a piece of information to indicate a "Mom, I'm home!" message. It is suggested that this might help to relieve the mother's worries about the child's safety. Some of the technology used in the Gustbowl design includes a pressure sensor, gyroscope, CCD chip, servo motor, organic led display and a computer. Figure 2.1 shows a gust bowl installation.



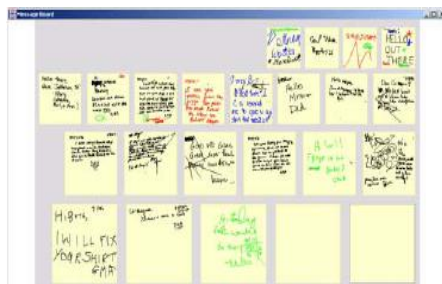
Figure 2.1 Physical and aesthetic issues for the Gustbowl

One family tested the Gustbowl artefact for a week but the results seem to reflect time demand issues. To interact with this artefact the mother had to stand by and be aware of the bowl in order to get her son's message. For instance, it was recognized that only six out of eighty messages were completely detected by the users. This technology should therefore use varied mechanisms to convey messages to mobile parents. In addition there was a low level of interaction between mother and son

which seemed to be associated with the lack of familiarity with the use of this type of technology. Thus, this work emphasized the importance of introducing the technology to parents to help them to grasp the interactive approach of the gust bowl. Furthermore, from figure 2.1 we can see the physical requirements for accommodating this technology which might constrain its incorporation in everyday environments.

2.3.2 Technology Probes

Technology probes [Hutchinson et al, '03] have been used to explore how ubicomp designs might support communication between distributed family members. The probes are particularly focused on studying inter-family communication and the extent to which these social interactions could change with the use of alternative technologies such as the messageProbe and the videoProbe. The messageProbe can be used to exchange digital post-it notes. The videoProbe helps with the sharing of still images. The technology used to build these probes includes a minicomputer, touch screen monitor, webcam, and tablet pc.



messageProbe



videoProbe

Figure 2.2 Physical and aesthetic issues within the design of technology probes

The messageProbe was tested concurrently in three households: parents with children, and two sets of grandparents. The videoProbe was tested in two pairs of household: two sisters and two brothers. Some of the social experiences with the technology probes show issues associated with domestic activities and variability. Regarding the messageProbe, most of the communication flowed between grandparents and children. This might be an indicator that parents were not engaged with the technology or that their available time for interacting with the probes was very limited. With regard to the videoProbes, we might observe aesthetic issues. For instance, figure 2.2 shows how hardware and cabling were concealed to keep the appearance of the videoProbes in tune with the aesthetic of the room. Additionally, one of the users allowed drilling into the wall of her flat to hang the probe, whereas

the other home owner preferred to make some space on a sideboard on which to place the probe, rather than disturb the building. Finally, the researchers argue there were different attitudes to the technology probes, each associated with the individual motivations behind the potential use of a probe, which suggest that adaptable or adaptive ubicomp tools are necessary in order to meet different users' needs.

2.3.3 ASTRA

ASTRA [Markopolous et al, '04] is another system that explores how different levels of social communication might be supported with technology. In particular, this work presents the use of mobile phones to capture users' experiences when outside the home. Using a mobile phone that supports picture taking, drawing and writing, users can record thoughts or moments. Information can be shared instantly via SMS, instant messaging or e-mail, or it can be stored in a "To-Tell" list. Individuals in the home can decide when to interact with the system and access that list. Here, a tablet PC represents the interface to interact with the ASTRA system, figure 2.3. The system is socially accessible, i.e. designers exploit today's mobile phone technology and desktop-like applications to offer a novel means of affective communication between family members. However, in spite of its social acceptance as a novel perspective on the use of this type of technology, it seems that its adoption is not guaranteed.



Figure 2.3 Does technology fit in family daily activities?

For example, during a two-week trial experience it was observed that participants started to share artistic information, but by the end of the first week they sent only pictures. So, on the one hand, we might argue that participants did not want a delay in sending the captured moment, but on the other hand, we might assume that there was a lack of felt need to communicate. Some participants reported, for example, that they took and sent pictures because they were instructed to do so. This also might be

associated with the novelty of the technology and not with its “fit” into participants’ daily lives: “participants would probably use it less if the novelty wore off”.

2.3.4 CareNet

This system aims to support caregivers and family members of elders through a care network [Consolvo et al, ‘04]. The motivation for building such a system is based on a social study that considered the extent to which caring for elders affects caregivers’ lives. Caregivers include not only family members but also others, such as nurses and doctors, who are concerned with the care for an elder. Problems in coordinating the care of an elder can include: responsibility, communication, distrust and unmet care needs. The system aims to support elders who live alone in their own home by offering communication facilities for the elder and for caregivers. For instance, the web-based CareNet display is used to receive and communicate information to support some of the elder’s everyday activities such as taking medication. This information can also be shared between caregivers, for example, to coordinate outings. The CareNet display is a tablet PC disguised as a picture frame (see figure 2.4). Although there is the potential for social acceptance of this type of support from both elders and associated caregivers, it depends on bridging the social contexts effectively with technology.

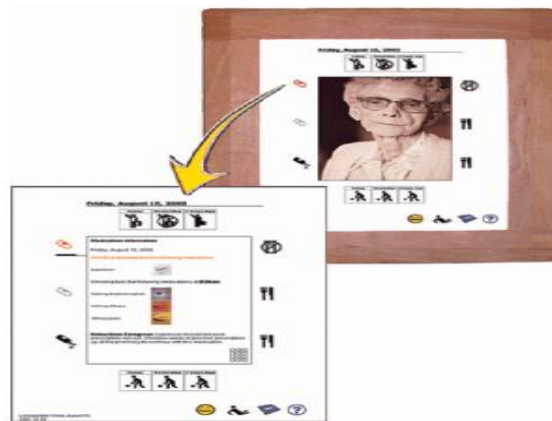


Figure 2.4 Pervasive technology is needed to enhance the CareNet system

There is no sensing technology deployed, for instance, to gather environmental information to infer the elders’ well-being or to update the system. In this work, this role was played by a receptionist who maintained communication with both elders and caregivers, and who updated the CareNet display using this information.

From this study of affective awareness we can conclude that novel uses of technology to enhance social communication are often welcome at least in principle. It is possible to observe a general interest in interpersonal awareness. However, we observed that firstly, systems must not overload or distract individuals in their daily activities; secondly, aesthetic issues should be taken into account when moving ubicomp technology into the home; and thirdly, usefulness and usability factors may influence the adoption of ubicomp technology.

There seems to be a genuine opportunity to augment social spaces with ubicomp technology, and for novel designs to enhance everyday activities. Therefore, we move next to consider work that has been focused on the gathering of context information from social activities in domestic settings.

2.4 Daily activities monitoring

In this section we consider context-aware experiences that support everyday household activities. Although most of this work is focused on supporting in-home aging scenarios, we also illustrate different approaches to the monitoring of people's activities and to the integration of sensing technology within the home. We will again highlight social issues in the acceptance of the proposed ubicomp services and systems.

2.4.1 *The Home Energy Tutor*

The Home Energy Tutor [Beckmann et al, '04] is a domestic system intended to monitor energy consumption from appliances. This particular user-ubicomp experience explores whether sensing technology can help the user to manage the home's ecology and whether the user might accept this kind of pervasive support. Five different sensing technologies are used: sound, motion, vibration, current and webcams. Sound, vibration and motion sensors monitor activity from working appliances. For example, the running of a refrigerator compressor can be differentiated from its steady state by any of these sensors. A further goal explores to what extent users are able to install the sensing technology. A package consisting of an appliance catalogue and wireless sensing devices was given to inhabitants who used this reference to attach sensors to appliances. An additional task consisted of

registering each of the sensors' barcodes to the system through the use of a handheld barcode reader.

The evaluation of this work, with 15 participants, included four phases: introduction, exploration, sensor installation and interview. Overall, the study measured the users' perception of the novel applications of this ubicomp technology and the physical and social issues associated with the sensors' installation. Although in general it seemed that this kind of ubicomp support might be accepted, there are some issues that we wish to highlight. Firstly, the introduction of new sensor technology or its application in an unusual way can confuse end-users:

“When familiar technology must be used in unusual ways... it is important to substantially disguise the underlying sensor, both in name and physical form.”

Secondly, aesthetic and interpersonal awareness are social aspects that might influence the acceptance of pervasive technology within the home. For example, some householders were worried about the use of adhesives, and the visible presence of sensors, which could damage the whole home aesthetic. Some parents also expressed concerns about the installation of sensors because they were worried that young children or even pets could reach them. Thirdly, the use of microphones and cameras caused concerns about privacy: “I got so freaked out because of the camera”. Thus, we can see that even when the utility of a technology is clear, users may still reject it:

“Technical issues become irrelevant when users are unwilling to install sensors for pragmatic reasons.”

2.4.2 Sensing from the Basement

Sensing from the Basement [Fogarty et al, '06] is another system that aims to identify activities in support of elders' in-home aging. This work suggests that by detecting activity that shifts from “normal” patterns it might be possible to identify “unhealthy” activity, e.g. signs of illness. This approach, rather than intruding into the living space with sensing technology, proposes the sensing of the water distribution infrastructure within the home. Microphone-based sensors are attached to existing pipes to monitor the flow of water. By sensing the cold water that enters

the home, the hot water flowing through the main pipes and waste water that leaves the home, this approach might help to identify, for instance, the use of sinks, toilets, showers and other appliances such as the washing machine. This information might therefore be used to sense indirectly the user's location. In spite of its novel approach, however, this technology is constrained to monitor the user's interaction with artefacts which are linked to the water distribution infrastructure.

Another technical issue with the use of microphone-based technology is its sensitivity to ambient noise: pipes are good conductors of sound. For example, it was found that the rattle movement caused by the air conditioner and the clothes dryer affected the collection of water flow data.

A further issue associated with the sensor's placement and sensitivity relates to the sensing of concurrent activities. For instance, it was not possible to distinguish concurrent activities such as the use of the bathroom sink when the toilet tank was being filled up.

2.4.3 STAR

The Simultaneous Tracking and Activity Recognition [Wilson, Atkeson, '05] system proposes to support elders' activities. As in previous work, the concept here is to offer safe home spaces that might help elders, as far as possible, to live independently in their own homes rather than in a care facility. The STAR system uses pervasive technology to monitor the health of elders. Location and activity are two kinds of context information used to reason about elders' well-being. A dense installation of binary (on/off) sensing technology is used in this experience: 24 motion sensors and 24 contact switches with beam-break sensors and RFID tags. Although the evaluation of this experience was focused more on the STAR computing capabilities, this work serves to illustrate potential physical and social issues if the STAR approach was used in today's homes.

Firstly, some of the technology used here is often classified as having a high power consumption, e.g. beam-break sensors, and we can assume that cabling issues are present. Secondly, an RFID tag disguised as a key ring needs to be carried by householders all the time so that the system can locate them at room level, an

approach that is often considered as intrusive. Thirdly, we wonder whether the tagging of artefacts affects or modifies their everyday use, e.g. what additional precautions should be taken with the contact switch installed on the fridge door?

2.4.4 BUMUS

The Bluetooth-based Ubiquitous Monitoring Unit for Sensors [Hwang et al, '06], BUMUS, is the hardware platform used to design a tool that monitors activities within the home. The approach aims to tracking elders' location and health-related activity. Technologies used within this home healthcare scenario include motion (7), sound (1), light (2) and flame (1) sensors and magnetic switches. These sensors, it is reported, communicate activity to a host computer via Bluetooth. Some of the context information gathered includes entering or leaving rooms, cooking tasks, interaction with artefacts and user's presence within a room. During the characterization phase of this sensing infrastructure participants were given a script with eight activities: watching TV, study, using the computer, filing, brushing teeth, vacuuming, walking around in the room and free exercise. Results from these controlled scenarios are promising from a technical point of view as it seems that cabling issues were overcome. However, because this work has not been tested in long-term use, we have some doubts about power issues, physical requirements for sensors' installation and the users' perceptions of this particular ubicomp approach.

2.4.5 Monitoring ADLs

The Activities of Daily Living system [Munguia et al, '04] monitors elders' activities such as eating, getting in and out of bed, using the toilet, bathing, preparing meals and housekeeping, by tracking interactions with artefacts, appliances and other home objects. For example, simple on/off switches are used to track use of the washing machine. In total, they used 77 binary sensors in one home, and 84 binary sensors in another to collect users' activities over 14 days. The subjects included a professional who spent her free time at the home and one 80-year-old woman.

Although we could discuss the social obtrusiveness of this approach in relation to the tagging of artefacts and objects, we prefer to remark on potential social concerns associated with the requirements to process information from large sensing deployments. For instance, to semantically label users' activities and their interaction with the artefacts, an electronic device was carried by each householder for fourteen

days; the tool beeped once every 15 minutes querying users for information about their current activities. The user selected from 35 different activities the one that best matched what he/she was doing at that precise moment. From this we would argue that the training of *smart* algorithms may require the distraction and overloading of users' activities. In this regard, some of the social issues encountered in this experience [Beaudin et al, '04] include the extra sessions of ethnographic work required to match real and sensed activities. This was necessary because participants did not always respond to the sampling tool, and also because their answers frequently did not match what was reported by the sensors. For instance, whereas a sensor reported interaction with the fridge the user reported leaving the kitchen.

In summary, what is seen from these experiences is the trade off between the usefulness of sensing technology as the mean to support householders' well-being and its intrusiveness within social settings. We realize that aesthetics, privacy, fears, time and other human concerns are present in most of these ubicomp experiences. In particular, it seems that systems that employ high levels of technology might face more acute social issues, such as the overloading and distraction of people's everyday activities. However, although technology seems to be far from being accommodated seamlessly in the home, it is perceived as providing opportunities to enhance householders' everyday lives.

The next section presents work that explores ubicomp facilities that are interactive and that allow some level of user participation and personalization within the running system.

2.5 User-ubicomp interactions

In this section we review experiences that are concerned in exploring user interactions with ubicomp technology. As the previous experiences may have indicated, much of the time the user appears as a simple producer and/or consumer of information. In this section we present works that explore approaches that allow a higher level of user interaction, but with a low level of ubicomp technology.

2.5.1 Squeeze

Augmented furniture is used to mediate experiences between co-located people within the home. The approach uses technology to maintain connectedness between families and loved ones who are not in the same physical space, e.g. parent upstairs and child downstairs. The design approach proposes the embedding of technology within artefacts with which family members' often interact. For instance, a disguised house-camera is used to take pictures while walking around the home; these pictures are immediately sent and displayed to a wall. Close to the wall there is the "squeeze chair" [Petersen, '07], an oversized sack chair which serves as the user interface for replaying the pictures. Interaction with the system is possible through the movement of the squeeze chair and through the direct use of labelled active zones, augmented by pressure and flex sensors and piezoelectric cable technologies. Although there are issues with the adoption of a projector as part of the home's furniture and perhaps with the interruption of household activities, this experience shows how a consideration of aesthetic issues might help the household to accept this type of ubicomp interactive scenario.

2.5.2 The Home Health Horoscope

Monitoring of family members' activities in the home is the central concern of the Home Health Horoscope [Gaver et al, '07]. One of its approaches is to sense some household activities as a means of identifying users' "well-being". Cupboards, doors and sofas are among the augmented artefacts. For instance, user interactions with a cupboard holding cleaning materials is monitored and associated with the cleaning task, and any disruption to this activity is considered as an indicator that something is going "wrong" ("unwell-being"). Nine mote sensors are used to collect data about the users' interactions with artefacts within the home.

Another approach used is to identify how householders socialize – how and when they gather together to watch the TV for example. To that end, the status of the kitchen door might be used as the first indicator: if the door is closed and if sensors detect activity on the couch and the TV is on, the systems might infer some type of social activity within the room. The output of the system is a printed horoscope which delivers "ambiguous" messages ready for the householder's interpretation; one such report might include "You are working too much, you might need a rest". Thus,

the Home Health Horoscope proposal is interesting for its novel approach to promoting user-ubicomputing interactions. However, we wish to point out some technical and social issues experienced within the three month trial of the Home Health Horoscope. First, nine wireless sensors were initially considered to tag artefacts, but ten additional wall-powered repeaters were also required to make the system work properly. There were also power issues with this technology, and the batteries needed replacing each week. With regard to the social context, some participants did not accept that some artefacts such as the cupboard had to be altered to accommodate the sensing technology, as it obstructed the way the artefact was used.

Another more sensitive issue was expressed in terms of what the technology might understand and interpret as the user's well-being:

"The system characterized her as too busy...she enjoyed being busy and would be unhappy otherwise."

2.5.3 The Information Furnace

The Information Furnace [Spinellis, '03] is a system that focuses on enhancing inhabitants interactions with technology. In particular, it is concerned with the development of a centralized ubicomp user interface through which a householder can interact to control appliances. Five different categories of use of appliances and artefacts are explored for their potential networked communication: home control, infotainment, security, communication and special purpose devices. Examples of these five groups include the central heating system, CD and DVD players, alarm-based security systems, answering machines and the microwave oven. The aim of the information furnace is to offer a single point of interaction between the user and these systems, thereby reducing the burden of using device-dependent control systems, e.g. keypads or remote controls. So the Information Furnace acts as a central hub for content, communication and control, and its interface represents a gateway for ubiquitously interacting with all these technologies.

This work could be discussed in terms of the technical perspective of building synergistic value-added services; or in relation to its inherent complexities for configuration and maintenance; or in terms of the issues arising from the physical requirements for placing the information furnace and cabling. However, we seek to

highlight its web-based user interface through which householders can interact with all home automation facilities. The UI appears to be a simple interface with little apparent complexity for the user. There is an additional facility to recognize speech commands at the main door entrance. In the same way, we believe that domestic ubicomp designs should offer easy and flexible interactive channels for end user interaction.

2.5.4 The Jigsaw Editor Tablet

The Jigsaw Editor Tablet [Rodden et al, '04] is a ubicomp prototype that can be used to automate some tasks of interest to the user. The aim of this user interface is to explore how participants become familiar with novel ubicomp technologies and how inhabitants are able to build new domestic services. For instance, if users want to build a system to monitor activity outside the entrance door, the user uses the Jigsaw Editor to select appropriate technologies, to interconnect these and to instruct the system to run the service. Additionally, users can configure the output channels to report events, e.g. speakers, WWW, PDA, and so on. It is the user, therefore, who decides what, how and where collaboration and interaction should be done. One great advantage of the Jigsaw user interface is its approachability; the drag-and-drop approach of assembling jigsaw pieces to end up with a ubicomp service seems to help people to engage with pervasive technology. Another of its visible advantages is that users can re-configure or adapt services at any time. This might be used to adapt the system's interaction and collaboration to current user needs. However, there are two potential issues to note. First, the Jigsaw Editor approach seems to be limited to the building of low level automation-based applications. How would one make available jigsaw elements to integrate reasoning layers rather than merely the logical interconnection of devices? In addition, the jigsaw is centralized, which requires the user to interact with the main computer to build or adapt services. We believe that it would be useful to take user mobility into account. For instance, a PDA could be used not only as a sink for consuming information but also as an extended jigsaw interface to allow the service adaptation.

2.5.5. e-Gadgets

This e-Gadgets study [Mavrommati et al, '04], home furniture and appliances are augmented with sensors and communication devices. These augmented artefacts expose their state and sensing capabilities to the Gadgetware Architectural Style

(GAS) user-interface in which users can build ubicomp applications. In a similar way to the jigsaw UI, the GAS editor explores how users might be able to master a tool to build, configure, deploy and adapt domestic ubicomp services. The e-chair, e-lamp, e-mat and e-book are some of the prototypes of the e-gadgets. For instance, the light, temperature and weight contexts offered by the e-desk could be interconnected to automate the desk environment for reading purposes. It is argued that with the use of the GAS and e-gadgets people might be able to shape their own automation-based environment.

Although it is argued that the ubicomp tool is easy to use, there are technical and social issues worth highlighting. Firstly, there is a need for technical assistance with the use of e-gadgets. When the authors say that someone else has to pre-configure e-gadgets to tailor these to the desired application, they appear to accept that their interaction may not be very friendly: “The employee in the store had to create a set of synapses among e-Gadgets’ plugs”.

Secondly, the configuration parameters that are accessible at the user level might not in fact be easy to use: “The identification and selection of capabilities is a task that depends on the user expertise”. Thirdly, this work highlights the importance of a “warm” introduction of technology to its users. In the particular case of e-Gadgets we might associate a learning curve with the use of and interaction with such technology, e.g. here it is suggested that the standard user of e-Gadgets should be a “technophile” who nevertheless will require a short introductory session to master the use of the GAS editor. Thus, as noted previously, usability issues can limit the acceptance of ubicomp technology.

2.5.6 Gate reminder

The Gate Reminder [Kim et al, ‘04] is a prototype that explores how technology might be used to enhance activities. In particular, it focuses on offering alarms to remind inhabitants about objects or artefacts before leaving the home. For instance, if a person is on his or her way to a meeting the collaborative gate could prompt them not to forget items such as the meeting report. However, this is a laboratory-based prototype and there are physical issues in the accommodation of the technology – large RFID readers and a display that hangs up on the front door.

We are even more concerned with some of the social issues around the approach used to interact with the Gate Reminder. First, the user has to feed the system with his or her identification. To that end the system trialled three approaches: speech recognition, video and RFID tags. The speech recognition approach failed because people had to remember what to say, which seemed to clash with their immediate activities, and because they found it strange talking to a door. The video approach also failed because users had to stop in front of the webcam for a few seconds in order to be identified. These two technologies seemed to disrupt everyday routines:

“Many participants expressed that they do not wish to be interrupted more than necessary when leaving home.”

With regard to the RFID technology, we note firstly that it may be complex to tag each of the artefacts of which users might want to be reminded. Secondly, the interaction between the user and the Gate Reminder seems to be quite intrusive: in order for the Gate Reminder to recognise about reminders, it is actually the user who needs to feed the system with most of the reminders. For instance, if the user wants to be reminded about the book he/she has to return to the library, the user must record the reminder for the system and only then is the Gate Reminder ready to prompt users before they leave home:

“...some participants from our user experience evaluation said they feel the Gate Reminder is rather a heavy system for simple reminding in daily life.”

2.5.7 Roomba

This is a “robotic floor vac” artefact [Forlizzi, DiSalvo, ‘06] designed to support some cleaning tasks. Roomba offers some facilities that might relieve householders of some of their cleaning “chores”, such as sweeping and vacuuming. As might be expected, this kind of ubicomp support was widely accepted. Householders who used it identified how some aspects of their cleaning tasks might be supported and how its use could also help to involve other family members in domestic activities. There were, however, some social concerns that indicate how the adoption of this kind of technology is affected by the social perception of the usability of “smart” technology. For example, from some of the users’ experiences with Roomba, it was recognized that people had high expectations of the robots’ intelligence and because of that they

barely accepted that the robotic technology might need a learning period; this might influence and possibly diminish its usability:

“I can’t understand... it will ram itself into a wall a dozen times before it decides ‘oh, there’s a wall there’.”

Another element observed related to home spaces. People realized that the robotic vacuum needed assistance to complete the cleaning tasks. For instance, Roomba needed help to clean under sofas, and the user had to sweep from stairs towards spaces accessible to Roomba.

Thus, if we consider all of the social factors that shape “living” spaces, including culture, age and number of family members, we observe that even technology which demonstrates its usability might have problems with adoption.

2.6 Summary

We have presented research on a number of different efforts to support people through ubicomp technology within the home. We have observed experiences which give support to elders who live alone in their own home and, to a lesser extent which encourage interpersonal awareness among family members who live in the same or other dwellings. Technology on different scales has been used to explore how ubicomp services could enhance householders’ everyday lives. Additionally, we have seen context-aware environments which aim to identify and understand users’ behaviour as the basis for ubicomp services that anticipate user’s wishes, intentions, desires, and so on. All of these are manifestations of how ubicomp might pervade the home. However, we have seen that the implementation of these user-ubicomp experiences has not been straight forward. When moving out of the laboratory, the accommodation of pervasive technology seems to be constrained by the features of the setting and in addition it might conflict with the conduct of domestic activities.

We summarize in table 2.1, the aims, technologies and issues for each of the four categories of systems under which we classified previous work. With the exception of the laboratory category we have labelled the systems with the level of user interactions (low, LUI, or high, HUI) and context collection (low, LCC, or high, HCC) supported by the systems.

As you might realize, we are not specific about the precise technology used, rather we refer to it as environmental sensing, embedded or high content sensing. High content sensing is linked to the use of video or audio technology. Embedded technology is one that has been “fortuitously” accommodated as an integral part of an artefact; and environmental refers to other more intrusive artefact-tagging approaches used to collect user activity, such as the use of weight sensors under the floor.

Setting	Aim	Technology	Issues
Laboratory	<ul style="list-style-type: none"> • Supporting elders • Analysing adults’ behaviours • Home’s space usage • Interpersonal awareness 	<ul style="list-style-type: none"> • High environmental sensing • High content sensing (video/audio) 	NA
Affective LUI LCC	<ul style="list-style-type: none"> • Aging in-home 	<ul style="list-style-type: none"> • PC-based designs • Low environmental sensing 	<ul style="list-style-type: none"> • interruptability • aesthetic • built resources • low usability (ASTRA)
Daily activity LUI HCC	<ul style="list-style-type: none"> • The home’s ecology • Aging in-home • Health and daily living 	<ul style="list-style-type: none"> • Medium to high environmental sensing • Bluetooth and wi-fi communication • High content sensing (video/audio) 	<ul style="list-style-type: none"> • aesthetic • sensor installation • privacy (e.g. tagging) • technology limitations • cabling • social obtrusiveness
Ubi-interactions HUI LCC	<ul style="list-style-type: none"> • Interpersonal awareness • Enhancing user’s activity • User-built ubi-services 	<ul style="list-style-type: none"> • Embedded technology • Low environmental sensing • High content sensing (video/audio) 	<ul style="list-style-type: none"> • technology limitations • aesthetic • learning curve • low usability (Gate Reminder)

Table 2-1 Summary of ubicomp support, context of use of technology and overall issues

From table 2-1 we could make two main observations that summarize issues around the implementation of domestic ubicomp experiences. Firstly, when a large quantity of technology is moved into the home it is likely to have physical and social implications. On the other hand, the user’s perception of the system’s utility might not be the best if collaboration is limited. Secondly, it was quite difficult to find experiences with high levels of context collection (HCC) and high levels of user interactions (HUI). This can again be associated with the limitations that the domestic context can impose on ubicomp technology, but also with the reliability of the sensing infrastructure.

The development of ubicomp experiences in the home is clearly not straightforward. Although we might find a relatively easy means of monitoring the user’s activity, there is often an implicit risk of affecting or altering people’s conduct [Crabtree, Rodden, ‘04]. We are using the lessons from these ubicomp experiences to propose a

framework that addresses some of the complexities. Firstly, bearing in mind the usability of the ubicomp system, our framework aims to accommodate technology that respects physical and social constraints. Secondly, system interaction and collaboration should take account of the changing social context, i.e. users should be allowed a high level of interaction with ubicomp systems in order to adapt the system's collaboration to fit their current needs. Thirdly, the interaction between users and ubicomp technology should be kept as simple as possible. Our framework, therefore, supports the design of ubiquitous computing experiences characterized by continuously present, integrative, and unobtrusive interaction [Ouslavirta, '04].

CHAPTER III

THE FRAMEWORK

3.1 Introduction

Chapters one and two reflected that approaches used to design domestic ubicomp experiences in laboratory-based settings cannot be applied in real homes. We have observed that laboratory experiences allow designers to focus on studying the interactions of users with computers and to be less concerned about other issues such as the type and scale of technology used. However, when considering real homes the practical integration of pervasive technology cannot be overlooked; technology explored in the laboratory might not transfer seamlessly into domestic spaces. For example, the experience with our cupboard prototype shows in particular that the physical requirements of accommodating sensing technology, which might include power and cabling issues, tend to affect the acceptance of pervasive technology in the home. On the other hand, we observed that when moving out of laboratory there seems to be a trade-off between the technology that can be accommodated to monitor user activity and the level of collaboration and interaction that is offered by ubicomp systems. We have seen that, typically, experiences with a high level of technology have more technical, physical and social issues than those with a low level of technology. However, it seems that the usefulness or usability of ubicomp experiences with a low level of technology might not be appreciated. Finally, we have seen that proactive collaboration might raise social concerns about the intrusiveness of systems. For instance, a system might wrongly infer that proximity to an artefact implies a user's intention to interact with the artefact. As designers of novel applications of ubicomp technology, we could incorrectly assume what and when collaboration and interaction has to be done, and on what terms.

This chapter presents a framework that has been defined to address these issues and that suggests a more socially acceptable approach to designing ubicomp experiences for today's domestic spaces. This approach takes into account the social aspects of the home such as the use of space within the home, cultural use of artefacts and the home's aesthetic when accommodating pervasive technology and defining context-aware collaboration for domestic ubicomp experiences, as seen in figure 3.1.

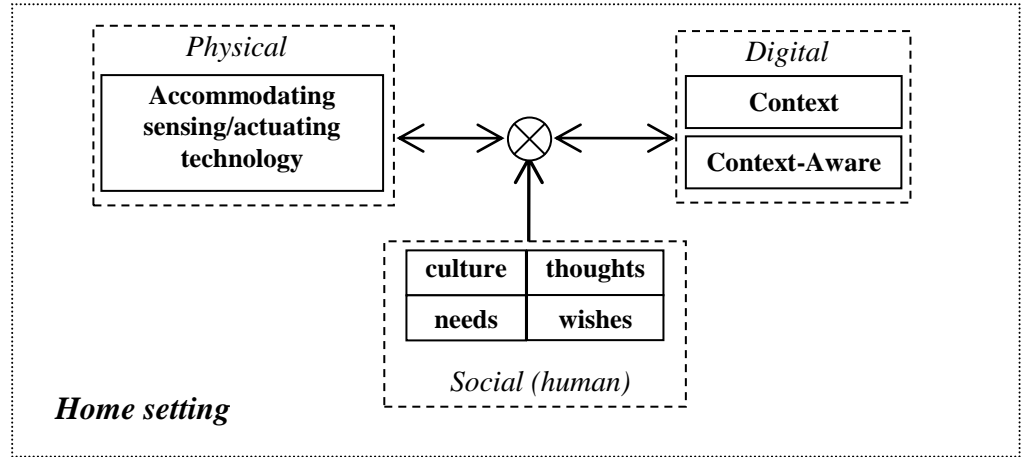


Figure 3.1 Interactions of social, physical and digital contexts

The next section presents the technological, physical, social and digital elements of our framework that must be accounted for in any ubicomp design that aims to find a place within the home. Section 3.3 describes two key considerations to create socially acceptable ubicomp designs. Section 3.4 shows how the framework’s elements interact while defining levels of adaptation for ubicomp systems. Finally, conclusions are given in section 3.5.

3.2 Reference architecture for domestic ubicomp designs

Ubicomp designs must be responsive to human and social environments. This section presents the architecture design elements that need to be considered if we seek to design socially accepted ubicomp tools. As seen in figure 3.1, our framework includes the joint management of three contexts: social, digital and physical, in order to offer an effective approach to designing ubicomp systems for everyday environments. We have previously observed that social considerations might influence how far the technology is integrated, and also the system’s awareness and collaboration, but we must specifically identify which social factors and physical elements should be accounted for while designing domestic ubicomp tools.

We start by describing the different elements that comprise the reference architecture to address the tripartite interactions (figure 3.1) supported by our framework:

- **Sensing technology** – Ubicomp technology should be harmoniously incorporated within the domestic space. The evaluation of potential technology to address the proposed social need should be done not only in

terms of cost and sensing capabilities but also with regard to the physical requirements of situating it within the home. For example, if considering the use of a webcam then we need to account for its weight and size.

- **Physical environment** – Accommodation of sensing technology should bear in mind to what extent built resources and social affairs might be affected. On the one hand, the designer can creatively define where and how technology might be embedded in or attached to the building skin. On the other hand, physical spaces are shaped by the way inhabitants make use of spaces and artefacts. These two factors will typically constrain the accommodation of pervasive technology in today's homes. For instance, cabling issues might affect or alter building spaces and/or the conduct of household tasks.
- **Context processing** – Information processing should not only exploit the available sensing capabilities but also reduce uncertainty and manage sensing reliability. Context processing might consider user involvement to negotiate obtrusiveness associated with the system's level of proactiveness. This consideration of the human activity might increase the ubicomp system's acceptability because users help to decide whether sensing uncertainty should be constrained or used to define collaborative services.
- **Collaboration** – Collaboration should respect cultural and human behaviours. The system's support should be offered in a sufficiently flexible way so that users are able to configure what kind and degree of collaboration might be accepted and under which circumstances.
- **Interaction** – Ubicomp experiences should be approachable. Mobility, usefulness and usability should all be taken into account while designing interactive mechanisms between users and computers. Individual activities must again be considered to reduce the system's obtrusiveness, for example, time demanding interactions.

The elements listed above are considered in a holistic design context in order to chart the degree of the technology's integration within the home and the degree of collaboration that might be offered to householders, as described in the next section.

3.3 Physical-social-digital interactions

This section presents two key factors considered by the proposed framework in the design of ubicomp domestic systems, and how the reference architecture elements should be applied in a socially-based approach. These key factors are the intersections of the social and physical and social and digital contexts. Figure 3.2 shows the physical and digital contexts that encapsulate the aforementioned elements. This indicates how we are considering domestic activities and their influence on these contexts.

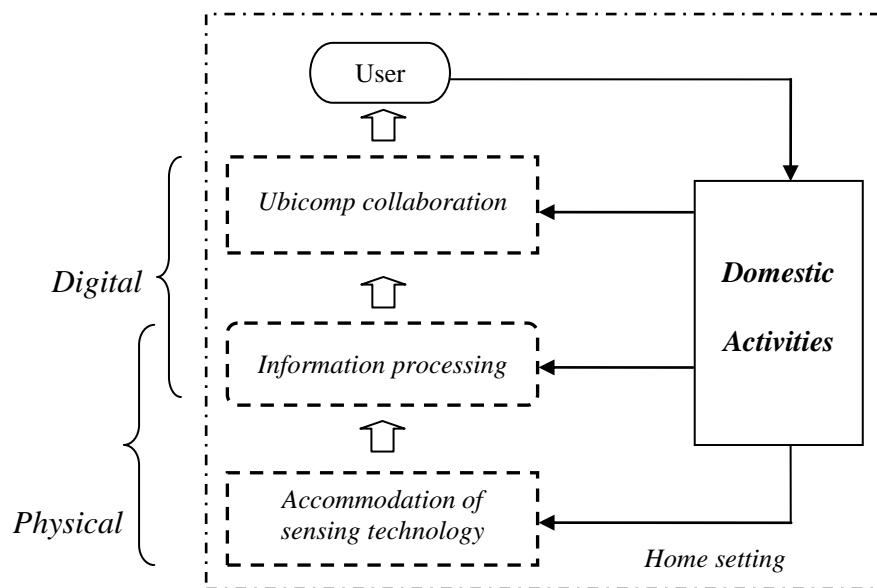


Figure 3.2 Family members' activity and domestic ubicomp designs

The next sections describe the management of these two key framework interactions: social-physical and social-digital. These interactions underlie our approach to designing ubicomp domestic systems.

3.3.1 Social and physical contexts

To date, technology tends to be assumed to be integrated seamlessly within domestic spaces, but we should certainly not take this for granted. If technology seeks to find a place within everyday domestic environments it first needs to be accepted by users. The proposed framework explicitly considers social factors of living spaces as an important issue when accommodating candidate technology within everyday environments. It uses a holistic approach in exploring issues of physicality in the sensing and physical environment elements of the framework. This will allow us to understand the possibilities and limitations for gathering environmental context information, as shown in figure 3.3.

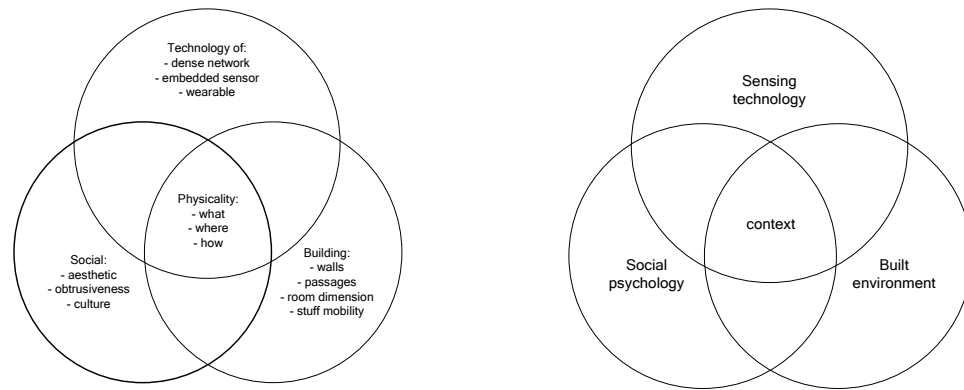


Figure 3.3 Physicality issues and the gathering of context information

Figure 3.3 (left) suggests specific options and issues that should be explored in order to understand issues of physicality around sensing technology, built spaces and social behaviour. To clarify these issues we describe next how specific questions – what, where and how – are addressed within the framework. In addition, we note some of the aspects of domestic activities that typically constrain the integration of pervasive technology within domestic spaces.

3.3.1.1 “What” technologies

Examination of technology is a two-fold process. It needs to be considered in terms of its sensing possibilities bearing in mind its intended purpose and the physical requirements of accommodating it within the home. This allows designers to explore choices of scale of the sensor deployment and the type of context information that can be collected. On the one hand, we should examine available technologies in terms of, for example, supporting the sensing of user location which is part of many ubicomp designs offering location-based collaboration. In particular, we could explore candidate technologies that use, for instance, a user-tagged or artefact-augmented approach to location sensing. On the other hand, we should specifically consider the physical requirements of the technology. For example, as well as its inherent physical requirements for power supply and communication channels, we should also account for those associated with its weight, dimensions and appearance.

By considering the use of a webcam, for example, we will find physical issues from its wired communication, but in addition we need to identify the DIY tasks that might be required for locating this device within the home.

3.3.1.2 Where and how to integrate technology

In principle, this depends on the kind of social support being offered. However, whatever the social support, typically some technology has to be accommodated within the home. This implies that either walls or artefacts are augmented as receptors for sensing technology. However, the question is where specifically sensors could go and how this could affect the natural setting. That is, the problem might not be finding a place for technology as such, but whether this accommodation of technology could be achieved unobtrusively. There are devices that need, for example, a particular position or orientation, and those that are constrained by the shape or size of the artefact. It is well understood that most existing homes were built without considering a place for computer technology and were unlikely to be purpose-built [Rodden, Bendford, '03], but the challenge is how the physical space could be best employed to integrate technology in today's homes.

Using the webcam example again, we should ask whether the ceiling is adequate to hold this device or, if it is placed in a corner of the room, how it will be attached. Another clear example is the cabling: could the home hide cabling paths for either communication or power supply? Regarding artefacts in the home, we should ask if their selection considers mobility constraint. For example, it might be the case that fixed artefacts represent the best choice for augmentation as mobile artefacts could increase erroneous measurements such as false sensor triggering due to loss of line of sight.

3.3.1.3 Consideration of human activity within the home

Finally, we need to explore how these design requirements can be harmoniously situated within the local social setting. In particular, is the proposal respectful of the users' well-being? There are two important social factors that should be considered in domestic ubicomp designs: aesthetic and space usage. It is recognized that the home is possibly the human's most valuable space, in which freedom and relaxation are usually part of the inhabitants' expectations [Crabtree, Rodden, '04]. Thus, technology should be integrated in such a way that the dweller's environment is disrupted to a minimum. Clearly, the dynamics of artefacts, in terms of upgrading or disposing of it, is a factor when determining where technology could go. In addition, we should consider circumstances in which the artefact's movement is associated

with everyday changes, e.g. we could find that the movement of artefacts might be associated with the room's re-arrangement.

If we consider the household task of cleaning, we should be careful that cabling does not unduly obstruct or alter the way inhabitants do that task, or, that incorporating sensing technology into artefacts does not limit their use. For example, technology attached to a window should not restrict its opening. Considering these issues, we argue that candidate technology has to be considered against social activities occurring within the home before deciding whether it should share the user's physical spaces.

So far, we have discussed how issues of physicality might constrain the degree of technology that could be accepted within today's homes. Our framework suggests an early consideration of physical spaces along three dimensions: sensing technologies, built resources and social aspects of domestic activities, in order to design socially acceptable computer-human interactions. From the various physical-social scenarios mentioned we conclude this section by arguing that when ubicomp designs move out of laboratory, it is often not the technology which supports the householder but the other way around.

3.3.2 Social and digital contexts

Users should be able to determine the level and nature of the collaboration of the ubicomp system. Once the physicality of the system has been considered, the designer can have a more realistic view of the type of information that can be collected from the sensing infrastructure. This sensor information needs to be explored to determine whether it will still address the identified social need and, if so, to what extent the system might unobtrusively interact and collaborate with users. That is, whether the systems' interaction should be modified, depending on social context, to vary the pro-activeness of the system's collaboration.

3.3.2.1 Information processing

First, we need to examine the level of information processing that the system might offer in terms of the types of context-information that could be extracted from the gathered sensor information. For example, when considering user location we should evaluate at what level this context information might be derived from the sensors'

data, e.g. at the level of room or artefact. Second, we need to explore the types of services that could be delivered to users. For example, it might be the case that environmental measures such as temperature and light are available from sensing points, which might allow the system to offer additional services. Third, we need to examine whether these potential services might empower or enhance the human activities. That is, whether any possible level of user-system collaboration might be considered useful and usable.

These three aspects of the social-digital interaction – available sensor information, services for collaboration and usefulness – might be affected by the dwellers’ needs, wishes, culture, and so on. Some ethnographic research has shown that fears of accepting or adopting ubicomp systems are associated with the extra work or the complexities that might be needed to master or interact with those systems [Meyer, Rakotonirainy, ‘03]. Our framework suggests exploiting sensor data to provide possible services but taking into account whether current services meet user requirements.

This does not mean that the processing of context information should be limited to that which is specifically needed for the user. Our framework promotes a maximization of the information collected from the available sensing technology (subject to its physicality constraints) in order to support any possible kind of service or collaboration.

In summary, this section presents three levels of association between social and digital contexts: establishment of context information, potential services and usefulness of collaboration. The management of these social-digital interactions might enhance the social acceptance of ubicomp designs due to the consideration given to the nature of the setting and human activity in “living” spaces.

From the exploration carried out so far of the interactions of both the social and physical and the social and digital contexts, it is clear that human activities can affect the scale of integration of technology and the potential collaborative success of ubicomp systems in today’s domestic spaces. The next section describes how the

elements of the framework link to domestic activities to support the system's adaptation.

3.4 Ubicomp system adaptiveness

So far we have described the elements that should be considered in a domestic ubicomp design. Two areas of human impact have been presented as key parts of the framework that might help to design socially acceptable ubicomp designs for everyday environments. These factors are considered while designing and defining unobtrusive collaboration for a domestic ubicomp system, which includes the design and management of some physical and digital aspects. We now describe how the framework's elements interact to account for individual activities to support adaptation in a running system.

We suggest the mechanisms and resources that can be used to adapt the system when the user or the user's needs change. For instance, as humans age they experience different stages of either development or detriment of psycho-motor skills. This might therefore represent a social factor requiring different collaborative services at different time. This level of system's adaptation can enhance social perceptions of the system's usefulness.

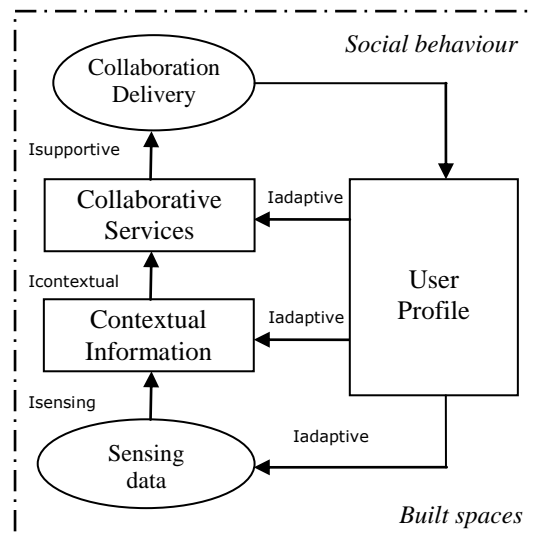


Figure 3.4 End-user interactions within domestic ubicomp systems

This consideration of the users' involvement suggests that there should be a representation of the user within the system design, which might be identified as the user's profile, as shown in figure 3.4. Here we recognize three levels of user interaction. Output information from the user's interaction ($I_{adaptive}$) with the sensing,

context and collaborative layers is indicated by I_{sensing} , $I_{\text{contextual}}$ and $I_{\text{supportive}}$ respectively.

I_{sensing} accounts for the dynamic incorporation (or reduction) of sensing information, which could be done either at the technology or information processing level. On the one hand, users might want to increase the scale of sensor deployment, and the system should be ready to be adapted to this new demand. In general, the sensing driver platform should be ready to accept new sensing technology. On the other hand, users might like to reduce the number of sensing points, and designs should provide an accessible mechanism to disconnect those sensors digitally rather than necessarily removing them physically.

$I_{\text{contextual}}$ refers to how designs should be ready to tackle sensing uncertainty. We believe it has been difficult for designers to reproduce laboratory experiences within home settings, and despite research to improve sensing reliability there is usually some sensing uncertainty [Huebscher, McCann, '04] or ambiguity [Gaver et al, '03]. Most approaches to reducing uncertainty from sensing technologies are managed either at the hardware or information processing level, but they are guided by the designer's criteria. Therefore, in addition to any AI, machine learning or data mining algorithms to process contextual information and constrain sensing uncertainty, our framework suggests that the user should also participate within this activity. For example, users might change the system's sensitivity to create different levels of collaboration, as described in the next section.

The next section suggests different levels of collaboration a system can make available to users to constrain the system's obtrusiveness.

3.4.1 Adaptive collaboration

Ubicomp systems should allow users to adapt the system's collaboration as they need or wish. This level of user interaction within the framework aims to reduce issues of obtrusiveness when supporting or empowering user activity.

The obtrusiveness of the ubicomp system can be reduced by attending to two user concerns:

- a) respecting the habits of users [Bell et al, '03]. A common issue for ubicomp research is whether or not proactive systems should lead human computer interactions, and the challenge is to establish how and to what extent such systems should take account of cultural and everyday characteristics of activities. Different levels of awareness collaboration can be offered to users as illustrated in the following section.
- b) accounting for current user's demands. If we are to take into consideration that users could interact with the system to modify I_{sensing} or $I_{\text{contextual}}$, then an additional interactive level is to allow users to configure the degree of report information that could fit within their current circumstances. This framework suggests different representation mechanisms to convey collaboration as described in section 3.4.1.2

3.4.1.1 Collaborative awareness services

Our framework argues that system's proactiveness can be constrained if users can interact with the system to adapt its awareness collaboration.

One approach could consider the availability of three awareness services:

- “digital-record”: within this level the ubicomp system runs in the background and any activity is recorded to a digital file (or equivalent). In this level nothing is reported to the user.
- “on-demand”: at this level the system runs in the background and at any time the user can interact with it to act upon or recover recent event/activity. Information is then delivered to the user.
- “continuous-monitoring”: this level allows users to monitor events and/or activity on a continuous basis. That is, the system is constantly reporting to the user about recent activity.

The system may shift between these levels of proactivity in order to adapt its collaboration with the user, and potentially manage obtrusiveness.

This approach might be extended to define changes of collaboration level linked to the continuous monitoring of events or activities, using a similar concept of activity zones [Koile et al, '03]. These zones, which are typically associated with sensing

capabilities, are defined to identify the usage of spaces within the room. For example, sensing points around the window could be clustered and their information processed to identify how the user interacts with this artefact. Thus, we might be able to identify “safe” or “dangerous” areas and thereby reduce obtrusiveness by permitting system collaboration from only the area that interests the user.

3.4.1.2 Collaboration delivery

Domestic ubicomp systems should collaborate unobtrusively with the inhabitants. This framework assumes the general ubicomp approach of delivering collaborative services via mobile devices. Although it is worth examining the mobile technologies available, this framework actually focuses on the kind and level of collaboration that could be delivered to the mobile user-interface. Before considering the type and degree of resources that might be available to support collaboration with users, it is necessary to consider the social factors that might constrain that delivery. Associated with these social considerations we may find that usability issues such as usefulness, ease to use and pleasantness, also depend on the individual’s current activities. Our design framework, therefore, should account for this and promote different mechanisms for collaboration.

As a general strategy this framework suggests a visual or graphical approach to a system’s user-interface. This visual representation of context should avoid unnecessary complexity in its usage and make its benefits clearly visible. That is, users should be able to see its applicability and approachability. In addition, to further reduce obtrusiveness, our framework also suggests the incorporation of hands-free elements. For example, sound to identify events or activity could be used without the user looking at the visual collaborative interface.

In summary, this section has considered the “runtime” individual activities that a ubicomp system should account for when allowing users to adapt the system’s collaboration. In addition to direct user consent to accept more sensing technology within the home, our framework suggests that this flexibility of ubicomp design might be achieved by including within the system a specific place for user interaction to reflect their current needs or wishes. Information given within this “user-profile” can be used by the system either to reduce obtrusive issues or to address new user

demands. Additionally, this framework suggests that domestic designs should address delivery and representation of contextual information by carefully considering potential usability issues.

3.5 Summary

Ubicomp designs must take account of social and individual aspects of human activity if they are to find a place within the home. Findings from the literature review and our initial exploration of technology and social contexts combine to form the basis of a holistic approach to designing context-aware ubicomp systems.

Considering the active involvement of users in ubicomp systems design and use led to the specification of a framework that aims to be less socially obtrusive in terms of not driving collaboration and more flexible in terms of its adaptation.

The convergence of social, physical and digital issues was used to chart how technology, built spaces, information processing and user's interactions must all be accounted for in the design of socially acceptable ubicomp systems. The importance of human and social factors in the integration of pervasive technology within the home is noted as it can also affect the degree of sensor information that might be collected and thereby the level of collaboration that might be supported.

We argued that once realistic contextual information has been determined, the flexibility of the system must be considered at three levels. First, the sensing platform should allow us to register and configure new sensing technology if users so wish. Second, users should be allowed to help the system with the processing of sensing information to reduce its uncertainty or ambiguity. Third, different levels of proactiveness or intrusiveness of the system's collaboration should be available to meet the current user's needs.

Finally, this framework explicitly recognizes that the delivery of collaboration should take account of efficiency and usability issues. With the support of this framework it should be possible to design socially acceptable ubicomp experiences. The next chapter describes in detail how this framework was applied to implement a ubicomp tool that supports parents with childcare tasks.

CHAPTER IV

IMPLEMENTATION

4.1 Introduction

This chapter describes the implementation of a ubicomp design which applies and demonstrates the framework seen in the previous chapter. We describe how the social, physical and digital contexts are taken into account when designing a ubicomp tool that aims to support householders. In particular, the tool focuses on helping parents with the supervision of children's activities.

The topics covered are the underlying motivation to support parental activities, and the ubicomp prototypes, context-aware room (CARoom) and parent-child companion tool (PChCT), implemented to test the proposed human-computer interaction approach. The implementation of the context-aware room addresses the interaction between the social and physical contexts, whereas the PChCT addresses the interaction between the social and digital contexts as established by our framework.

The consideration of the social and physical contexts and the implementation of the Context-Aware Room are illustrated in section 4.3.1. The consideration of the social and digital contexts and the implementation of the Parent-Child Companion Tool are described in the implementation of the Parent-Child Companion tool in section 4.3.2.

4.2 Social motivation

Studies show that domestic labour can be time-consuming [Ramos, '03]. Moreover, the attendance to domestic work may be more stressful if both parents have full-time jobs and child-rearing activities are included [Baxter, '00], [Buber, '02]. Childcare and household work can require up to 50 hours of housework [Denning, '04], and for parents the concurrent attendance of household work and childcare may be unpleasant [Sellen et al, '04]. In their study, for example, some parents considered that cooking together with caring for young children is sometimes hard to manage; others made clear that in order to carry on with the housework children need to be kept occupied.

So from this brief survey of the demands of home management, we find a fertile social context to explore how ubicomp systems could help parents.

To explore further opportunities for domestic ubicomp support within everyday activities we consider work in which householders expressed what they might want or expect from smart technology if it is integrated within the home: “*Smart technologies might be very convenient on really busy days*” [Green et al, ‘04]. Of particular interest are parents’ suggestions for “safe” spaces for children. Although they appear to accept smart technologies it is not clear what they might expect in terms of collaboration. We therefore explored other social scenarios in which participants pointed out that ubicomp tools might find a place within domestic environments if they are integrated within the family’s well-established organizing systems: “*Technology should provide new opportunities that do not restrict how people come to order their lives*” [Taylor, Swan, ‘05]. In particular, they highlight the ubicomp opportunities to help mothers with home child-care related matters.

In addition we explored ubicomp opportunities for supporting parents in the home, concerned with the interpersonal awareness of family members [Neustaedter et al, ‘06]. Their work suggests that interpersonal awareness in the home might help parents to identify the location, activity and status of the other family members. This perspective is used to identify the level of interpersonal awareness that might be needed by parents to supervise the whereabouts of their children. More specifically, we found that children’s accidents are widely researched [Clements, ’56], [Langley et al, ’83], [Macgregor, ‘07], and in particular that children under 5 years are the family members most subject to accidents within the home. For instance, in 2002 in the UK alone almost 5000 children aged under five were taken to hospital as a result of an accident in the home [Child Accident Prevention Trust, ‘04].

To summarize, our motivation builds on studies demonstrating that younger children may be exposed to hazardous situations, that this might be a good opportunity for ubicomp systems to support parental awareness, and that this kind of ubicomp support might enhance the management of the household. However, we must bear in mind that people seem to perceive system collaboration as something that should not conflict with how they run their household within their own culture. Before we

describe how the framework is followed in order to implement a ubicomp tool to support some of these parental activities, we present a hypothetical scenario that illustrates the kind of domestic ubicomp support proposed.

Nelly is the mother of a fourteen month old child, called Marya. She usually starts the housework around 7:00, while Marya is still sleeping. When Nelly is in the kitchen, the child wakes up. The ubicomp system sends the picture of Marya's bedroom to the available output device in the kitchen at the same time that the gates at the stairs are locked. Using this media information Nelly can observe Marya's behaviour while finishing the cleaning task in the kitchen. After having breakfast, Marya spends her time watching TV or playing with the "smart toys". Mum is tidying the bedrooms. When work in the bedrooms is completed Nelly goes to Marya and together they watch TV programs; because the system identified that mother and child are together it stops reporting Marya's activity. Later, mum goes to prepare lunch. Marya goes with mum and following her curiosity tries to open the cupboard doors, but the system has detected that the child has no permission to use this or other kitchen items, and it securely locks these. Later, Nelly has left something cooking for dinner while she is ironing clothes in the bedroom. Marya, who was playing in the living room, goes towards the kitchen looking for mum. After realizing she is not there, she is curious about the oven. The system has detected the child's movements and a warning message is immediately sent, together with a picture of the kitchen, to the available display in the bedroom where Nelly is ironing. Nelly uses the available ubicomp resources to get the attention of the child and uses her mobile device to adjust the burner level. Mum carries Marya upstairs and prepares her for a nap; the system adjusts the central heater system to a suitable temperature.

The above scenario reflects a specific but rich example in which computers might be used to support everyday tasks in the household. We present the context-awareness required for a system that supervises children's activities.

Considering that falls, burns, scalds and poisoning are the common accidents to which young children are exposed, we start by classifying home artefacts, furniture and appliances into three categories: high-risk, medium-risk and low-risk. High-risk

artefacts are those that are hazardous or dangerous such as the fireplace and electrical sockets. Medium-risk artefacts are those with which a child has to interact in order for it to represent a danger. For instance, a cupboard becomes unsafe only if a child attempts to open it. Low-risk refers to “safe” artefacts or spaces with which the child likes to spend time, e.g. the TV. Figure 4.1 shows the labelling of these artefacts; we use the common colour code to signal risk levels: red for high, yellow for medium and green for low level.

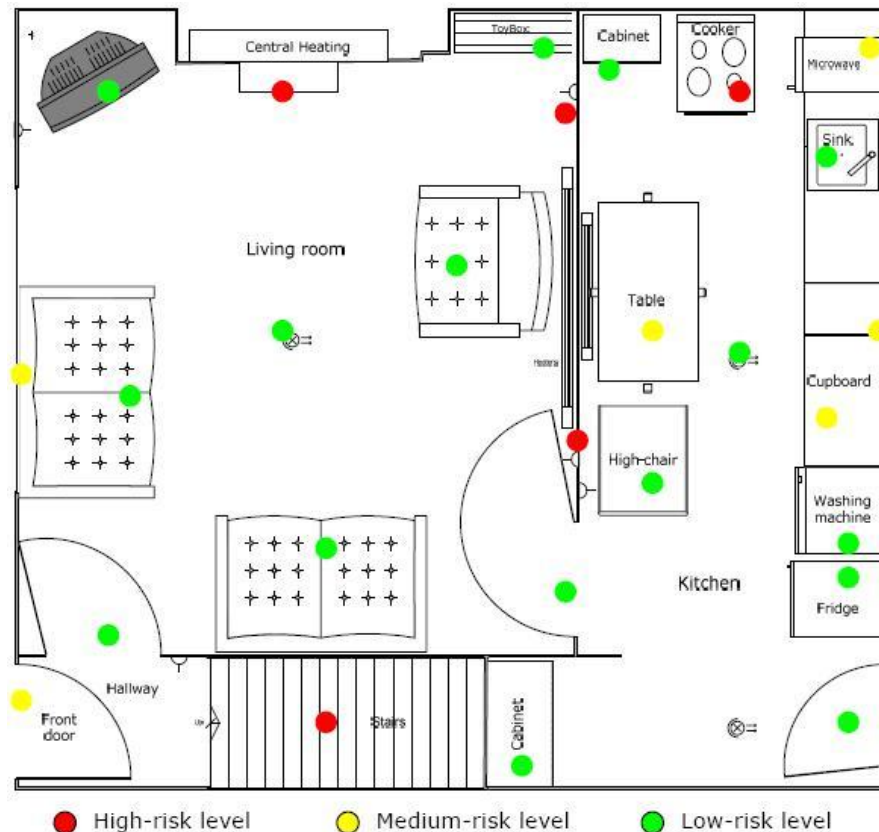


Figure 4.1 Labelling relevant artefacts and appliances within a home

Considering that relevant artefacts and appliances can be tagged or embedded with sensing technology, we can consider activity-aware spaces to monitor children’s whereabouts and activity.

4.3 Framework implementation

Having considered the social motivations we are in a position to apply our framework to the design of a ubicomp tool that might support parents in the childcare task. We have identified potential artefacts that can be monitored or augmented with technology to provide awareness of the home space. Next we have to identify what, where and how technology should be integrated within the room spaces and whether

information collected by this technology is sufficient for what parents might expect from the system's collaboration. In other words, we should explore the social and physical contexts in order to identify the kind and degree of sensing technology that can be moved into a real home (framework section 3.3.1), and the social and digital contexts in order to evaluate potential facilities for system's collaboration and user's interaction (framework section 3.3.2).

Table 4-1 outlines the key points to be addressed by the context-aware room (social-physical) and the PChCT (social-digital). The table identifies the scope for each of the different levels of interaction between the social, physical and digital contexts. For instance, the home space factor indicates that an acceptable interaction between the social and physical contexts requires that both the physical resources and the social context of the family members' activities are together taken into account before deciding where and how technology is accommodated within living spaces.

Framework's key factors		Social context
Physical	Candidate sensing technology (<i>what</i>)	Explored and selected according to the nature of the social support required
	Home space (<i>where and how</i>)	What the technology needs; what the home and/or living spaces might have available – practical constraints, aesthetics.
	Occupant interaction *	Flexibility to allow users to adapt/re-arrange sensing architecture
Digital	Context information	Available context information is sufficient for the representation of users' activity and the support of the aware collaboration.
	Collaboration	Usefulness and usable collaboration. Socially respectful in terms of unobtrusive support
	Individual's interaction *	Facilities to allow users to adapt the system's interaction

Table 4-1 Social, physical and digital context interactions

* dynamic user participation

The next section explores how candidate technologies can be part of the domestic context-aware space.

4.3.1 The aware room – social and physical contexts

We have argued that ubicomp designs must be responsive to human and social environments and as such we are avoiding tagging people but instead augmenting artefacts. From our experience with the context-aware cupboard prototype and the lessons from other work such as “Map of our lives” [Aipperspach et al, '05] we realized that social issues arise when wearable technology is used to track the user's location. We have also pointed out that while people with any disability (or elders) might accept to wear a tag other family members might not. In particular, we argue

that young children can feel uneasy wearing a tag and attempt to remove it. We decided therefore to use the approach of tagging artefacts. The following section illustrates then how technology was explored and moved to the context-aware room prototype.

4.3.1.1 “What” technologies

The first part of considering the social and physical contexts is to consider what technologies (section 3.3.1.1) can be available to support the context-aware domestic system. Given that collaboration with parental tasks requires information about the child’s whereabouts, proximity to hazardous artefacts and localization at room boundaries, we reviewed off-the-shelf technology might be readily applicable to our system. We find that light, temperature, magnetic, sound, video, motion, vibration, weight, distance, current and voltage sensors are pervasive technologies typically used in ubicomp experiences that monitor location and user’s activity [Welch, Foxlin, ’02], [Beigl et al, ’04], [Schmidt, Laerhoven, ’01]. It was also realized that these technologies can either wired or wirelessly communicate with a host computer. Although considered the use of the wireless devices was discarded because, as for the author’s knowledge, wireless-enabled sensing devices are readily available only for environmental sensing [Beigl et al, ’03] such as light, heat and humidity. These sensing capabilities might only partially meet the awareness needed for the home spaces. It is also possible to use a large number of on/off state wireless sensors to track human activity [Munguia et al, ’04]. This approach could also contribute to the awareness needed by the context-aware room, but it has limitations; for instance, it might help to sense presence on the sofas or interaction with a window, but not the fireplace. It seems that wired technology is the better choice.

In short, we therefore decided to use wired technology and to address its associated cabling issues. To that end we explored three options: EZIO [EZIO], ARDUINO [ARDUINO] and PHIDGET [PHIDGET]. In fact, we preferred the Phidget technology because this has readily available motion and distance sensors, which are easily plugged into a host sensor board; the others need an additional interface to connect each device to the host board. Beam-break sensors were also considered for the aware rooms as these help to monitor activity at door level. Figure 4.2 shows the motion, distance and beam-break sensors.



Figure 4.2 Sensing devices used for our context-aware room prototype

Distance sensors can help to sense proximity to artefacts; motion sensor can sense activity in the centre of the rooms, and beam-break sensors can sense activity in doorways. The next step is to identify where and how each technology will be installed.

4.3.1.2 “Where and how” to integrate technology

The other issues of physicality for social and physical contexts considered by the framework are “Where” and “How”, which suggest that the integration of technology should be unobtrusively accommodated in the home (section 3.3.1.2). This section then address these factors by considering the potential disruptions to built spaces and family members’ activities.

Once candidate technologies are selected these must find a place to be embedded or an artefact to house them. This analysis includes the examination of the degree of integration of technology, and its impact with the degree of collaboration to be offered.

Considering the apparent physical facilities of the home spaces, we argue that the location of the motion and beam-break sensors is broadly identified: centre of the room and door’s frame respectively, but not for the distance sensor. The first question is how to tag artefacts with a distance sensor. This sensor can go on the fireplace, radiators, outlets, oven, cupboards and fridge but it is difficult to tag sofas, the kitchen table, the sink, and windows. Problems with tagging these artefacts (due to mobility and/or aesthetic issues) are considered in section 4.3.1.3.

In response to the constraint of tagging artefacts we re-defined the dimensions of our aware spaces and reviewed the extent to which this might affect the social support

provided. Firstly, we could assume that for young children entry to the kitchen can be forbidden, unless supervised by the parent. Secondly, the reception area has few artefacts or hazard sites to be aware of. Thirdly, we could take advantage of the living room's location and use it as the key room of the awareness approach. We could consider, for example, the hallway as an *alert* area, the kitchen as a *warning* area and the living room as a “*safe*” area. These awareness areas are used to indicate the risk level that can be associated to each of these home spaces. Children's explorations around the kitchen can be more hazardous than their attempts to go upstairs. With regard to the living room it might initially be considered as a “safe” area as we could assume this as the room used to keep children entertained while parents complete the household work. Nevertheless, because the living room is housing the sensing technology we can use sensor information to define in runtime (by continuously monitoring activity) the risk level of particular spaces within this room, or also identify an entry to riskier areas – kitchen or hallway. To inform parents about the child's presence either within the *alert* or *warning* area we can consult the data from sensors on the doors of the living room.

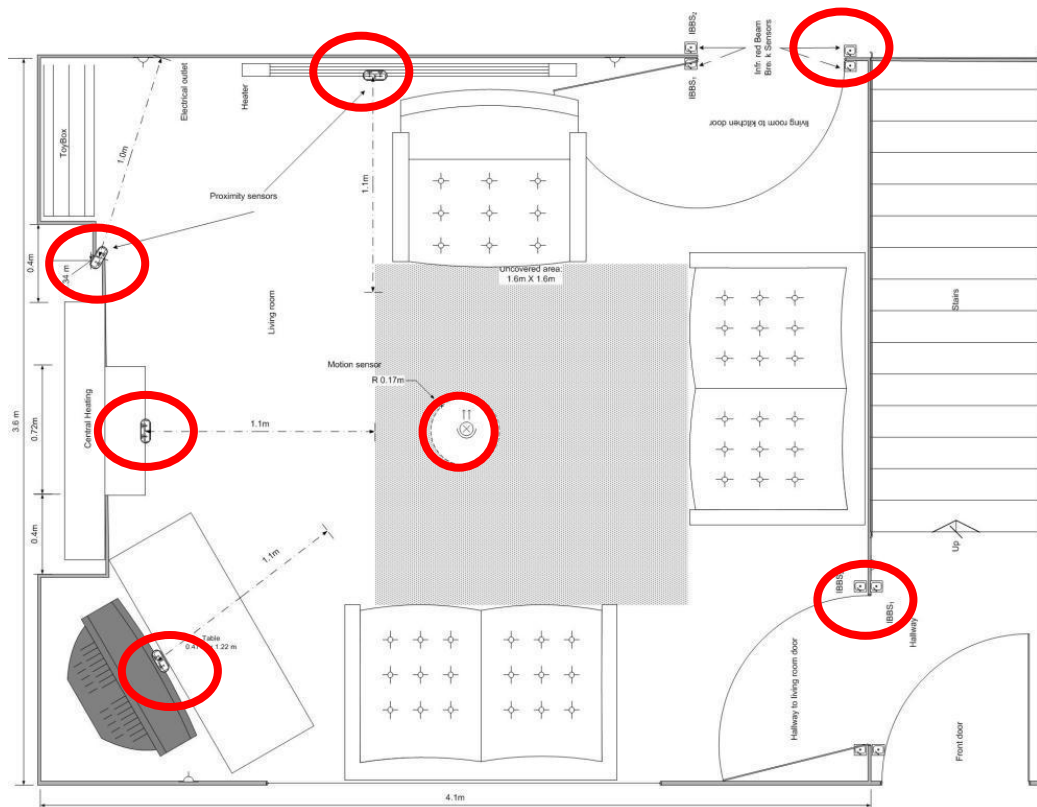


Figure 4.3 The context-aware room and its sensing capabilities

Treating the hall and kitchen as large labelled awareness areas allows us to reduce the physical requirements and aesthetic issues; however, it also reduces the potential

awareness of the system. Figure 4.3 shows the revised context-aware room design and its sensing technologies; the grey area around the motion sensor is an area that remains unsensed. To counterbalance the lost of sensor coverage within the living room we decided to include a webcam, which is installed in one of the corners of the room.

Once we have defined “what” and “where” technology could go, we then need to determine “how” to attach sensor devices to artefacts or walls. Specifically, we should account for possible damage to artefacts, walls or home spaces during the sensor installation. For our room prototype, for example, the webcam was disassembled to reduce its weight and thereby facilitate its installation using only sticky tape. The infrared diodes from beam-break sensors were also disassembled to allow easier installation and to avoid obstructing doors. The beam-break sensor boards were then semi-concealed along the door frame and held in place using small nails and tape. A harness was made to hold the motion sensor beneath the lampshade. Distance sensors were attached using Velcro. Even so, although reduced, there were unavoidably still some physical and aesthetic issues with the accommodation of this sensing technology.

4.3.1.3 Activity of family members and integration of technology

The integration of pervasive technology into real homes cannot be overlooked. Our framework supports the design of socially acceptable ubicomp designs and as such it considers effects on not only the built space but also on human activity (section 3.3.1.3). This section offer an additional perspective on how the addressing of social issues, as illustrated below, might constrain the degree of integration of sensing technology and thereby the collection of context information. In particular, we present three aspects of everyday family life – culture, activity and aesthetics – that influenced the integration of sensing technology within the context-aware room prototype.

- **Cultural ways of attending to housework:** these can affect the allocation of technology or the collection of activity data. For example, figures 4.4a and 4.4b show how radiators are used to dry clothes. How often does this occur and for how long? Is it the easiest means to dry clothes if compared with drying clothes outside home? Does it mean that the home does not have a

drying machine? We might want to explore these social and cultural considerations to determine whether it is worth tagging the radiator to monitor activity close to this artefact. For example, if the radiator is covered by clothes during the night, obstructing the sensor, this would not affect the collection of data as one might expect no activity during this period.

- **Family activity:** several individual and social factors shape family-members activities within domestic spaces – family size, ages, the presence of young children, economic status, religion, culture, and so on. For the context-aware room prototype the presence of young children affected the installation of sensing technology. Specifically, the presence of young children can mean that furniture and other artefacts are often moved. Figures 4.4c and 4.4d illustrate an example where the parents have re-arranged artefacts to prepare a “safe” area for children to play. Parents are likely to use other resources to make safe the home space used by children, e.g. gates for doors and guards for the fireplace. Moreover, the artefact’s mobility can limit the use of wired or wireless sensing technology. The movement of artefacts will cause sensors to vibrate or change their orientation, or may loosen the sensors. In addition, the child’s stage of development, and height, is likely to affect the installation of sensing technology. Two children of the same age can be quite different heights, so special care must be taken in placing a sensor in its final position. For example, we cannot attach a distance sensor in the middle of the TV screen; the height of beam-break sensors on the living room doors is critical since these are an important resource for distinguishing parents from children.
- **Aesthetics and comfort:** from figure 4.4 we can see at least three different rearrangements of artefacts. We believe that many of these are related to aesthetics and comfort. The change of decorative flowers (figs. 4.4a and 4.4b) on the top of the fireplace, the disappearance of the armchairs or the rearrangement of the sofas surely depends at least in part on these factors, to be considered when designing for the home. For the activity-aware room the installation of the webcam in one of the corners of the room was contentious in this respect as was the final number of artefacts tagged with sensors. It was also requested that cabling be kept out of sight by, for instance, running it under carpets.



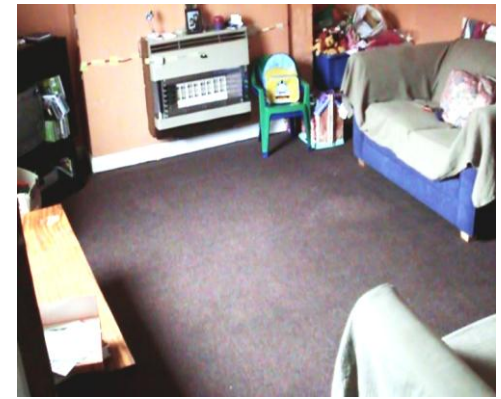
a) "arm chairs are re-arranged to make space to dry clothes on the radiator"



b) "drying clothes on the radiator, one of the armchairs disappeared, and new flowers are on the fireplace "



c) "room spaces are arranged for children to play"



d) "no more armchairs, decorative table and sofas re-allocated"

Figure 4.4 Family members' activity affects integration of technology within the home

The following section illustrates how domestic activities not only affect the integration of sensing technology but also the processing of context information and the implementation of the system's awareness.

4.3.2 Social and digital contexts

Once issues of physicality have been considered and the type and degree of integration of sensing technologies determined, as defined in the framework, we should then examine the context information that can be collected and the degree of collaborative support that can still be offered by the system (section 3.3.2). First then we summarize in table 4-2 the different levels of context information that can be gathered from sensing technology for the context-aware room. We should bear in mind that the doors of the context-aware room also help us to identify whether the child enters the *warning* room (kitchen) or the *alert* space (hall).

Sensor devices	Number	Goals	Context information
Distance sensor	4	Sense proximity to the television, fireplace, toy box and radiator	Activity at artefact level
Motion sensor	1	Sense activity around the centre of the room	Activity at centre of the room
Beam break sensor	4	Identify child or adult	Location at room level
Webcam	1	Offer a picture of the room	Activity at room level

Table 4-2 Sensing technology integrated within the aware-room prototype

Before describing how the processing of the sensor information needs also to take into account some aspects of domestic behaviour we briefly describe how we collect information from the sensors.

Context collection with ECT

The Equip Component Toolkit (ECT) is a software platform that can be used for system prototyping [Greenhalgh et al, '04]. ECT's architecture makes it possible to interconnect diverse physical components. Hardware components are registered with corresponding software components thereby making them available to developers of end-user applications. Figure 4.5 presents the ECT's general architecture.

Programmers, designers, end-users

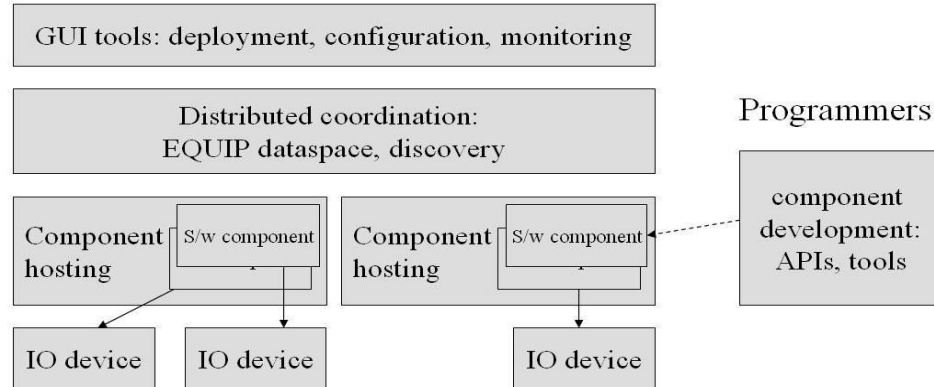
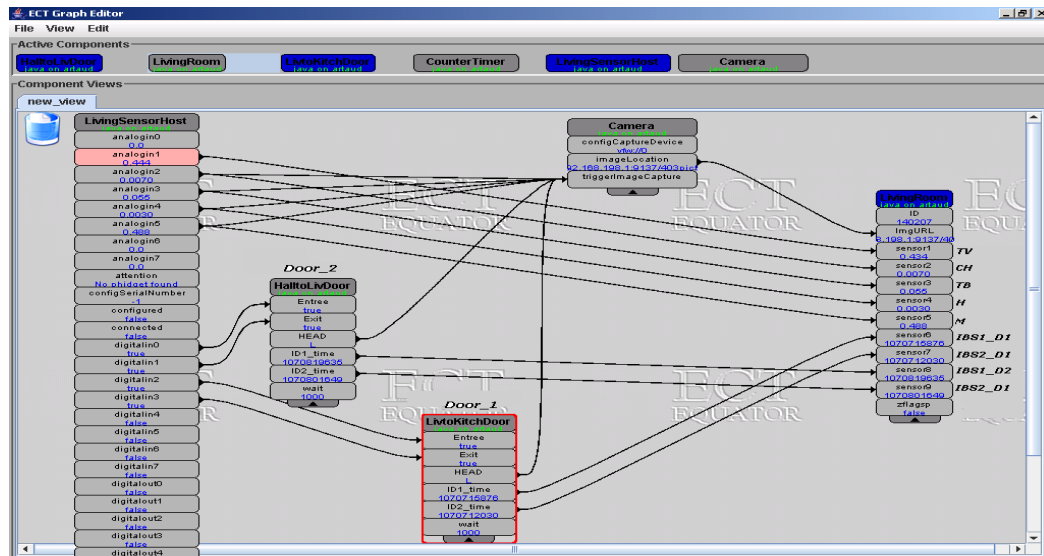


Figure 4.5 ECT architecture [ibid]

ECT has software components for a diverse range of technologies such as WWW, video, audio and hardware interfaces for motes, RFID, smart-Its and Phidgets. We used ECT's facilities to gather and record activity information, as seen in figure 4.6. We used a Phidget interface, "LivingSensorHost" (left), to read information from all of the sensors' devices and a webcam (centre) to capture an image of the room each time an event occurs.



Television (TV), fireplace (CH), toy box (TB), radiator (H), motion (M), hall-living door (IBS1_D1 and IBSD2_D1) and living-kitchen door (IBS1_D2 and IBSD2_D2)

Figure 4.6 ECT collects sensing information

The components labelled “Door_1”, “Door_2” and “LivingRoom” are JavaBeans components additionally built to process events from the beam-break sensors and to record sensor activity, respectively. Each time “Door_1” or “Door_2” detects an event from any of the beam-break sensors the system time is reported to the “LivingRoom” component. The “LivingRoom” component also records activity from all of the other sensors and the reference to the picture of the room that correspond to the sensor event.

Outside the ECT’s environment there is a java program (“Domestic Monitor Server”) listening to changes with the “LivingRoom” log file. Each time new activity is detected it is processed to implement collaborative behaviours. The “Domestic Monitor Server”, for example, identifies the source of the current event, the magnitude of its signal and its associated picture of the room. As illustrated in the following sections, this information is also processed to identify, for example, proximity to artefacts and thereby levels of collaboration

4.3.2.1 Information processing

Digital and social contexts are taken into account to maximize the sensing capabilities of the system in order to investigate the collaborative services that could be offered to support householders (section 3.3.2.1). For the context-aware room prototype we have selected sensing technology and identified the kind of context expected from sensor information. This section therefore describes how context

information is used to identify levels of collaboration to support parental tasks. Concurrently, we consider social factors of domestic activity that constrained the use of the fully sensing capabilities.

We have already mentioned that the prototype system should identify activity from proximity data and/or motion events. However, the critical element is the processing of activity data from the doors' sensors. The system should be able to distinguish between adults and children. Moreover, it must identify whether the child is alone within the room; in order to reduce intrusiveness with regard to parent's activity. First, therefore, we discuss how the information from beam-break sensors is used to identify a child's location at the room level.

Location at room level

The two sensors installed along each of the door frames are in different positions. Using the room's floor as the reference, one of the sensors is situated 40 cm (SL) and the other at 150 cm (SH) along the door frame. Considering these sensors as binary switches, we have four possible outputs as seen in table 4-3.

The "Not valid" event in table 4-3 is considered because we do not expect single events from this sensor. In contrast, events from sensor SL might be associated with child's presence. In the case of parents' activity, the sequence of these sensor events is important. For example, the sequence $SL \rightarrow SH$ might imply that the parent has entered the room, while the sequence $SH \rightarrow SL$ might imply that they have left.

SL	SH	Description
0	0	No activity
0	1	Not valid
1	0	The child enters/exit the room
1	1	The parent enters/exit the room

Table 4-3 Activity from beam-break sensors

Everyday activities which complicate the processing of information to determine location at room level are as follows:

- **Adult's activity:** typical human walking movements influence the activity information from both beam-break sensors – the lower sensor (SL) is usually triggered twice. The first event is due to the forward movement of the first leg, the additional event is associated to the other leg swinging to take its turn

in a walking cycle. The presence of these two events from the lower sensor required additional processing to classify them.

- **Household work:** we have already argued that there are different (culturally variable) ways of attending to household work. In particular, we found that activities associated with the cleaning task can generate uncertain events from the beam-break sensors. For instance, when sweeping/vacuuming the carpet the brush/vacuum might trigger any of the sensors. Moreover, the human movements associated with some types of household work can cause additional events, e.g. when a parent bends down to pick something up from the floor.
- **Parenting activity:** there are additional social issues affecting information from the beam-break sensors that are directly associated with parenting activities. For example, if the parent enters/leaves the room carrying a child or pulling a buggy through the doorway thus will affect what the door sensors can detect.

These observed human behaviours increase the amount of information processing needed to distinguish an adult from a child, given the sensing information.

Activity at artefact level

Information from Phidget distance sensors is used to determine the proximity of children to artefacts, including the TV, fireplace, radiator and toy box. Together with information from beam-break and motion sensors, proximity information can help parents to identify both how the child uses the spaces in the home and whether or not their child is close to potentially risky artefacts. The Sharp GP2D12 sensor, part of the Phidget distance detector, quotes a sensing distance between 10 cm and 80 cm, but further explorations with this technology have shown that the sensors are able to detect activity at 110 cm and over (appendix B). However, it was also realized that with objects beyond 70 cm the sensor accuracy decreases. Thus, we consider two scenarios: one constraining sensing range and the other allowing unconstrained sensing. The disadvantage of constraining the sensing range is that the overall awareness of our room prototype might be reduced: our uncovered sensing area will

increase (see figure 4.3). On the other hand, if we allow an unconstrained sensing range we must deal with more uncertain or ambiguous proximity information.

We decided to use an unbounded sensing approach, arguing that parents might be interested in any available information from the child's activity if they are alone within the context-aware room. That is, parents can decide what level of activity-information is of interest. Therefore, the processing of proximity information is deferred until the design of the collaborative approaches; this is considered in section 4.4.1.1.

Next we present some of the domestic factors that complicate the processing of proximity activity.

- **Cultural use of artefacts:** it has already been said that, for instance, the use of radiators to dry clothes might affect the collection of activity data. For our room prototype we found variable proximity data when clothes were left drying on the radiator because sensors were blocked. We also found at one point random variation in sensor data that was due to a broken sensor board. After reviewing the recorded material, we realized that the constant activity of placing and removing clothes from the radiator had cracked the sensor board.
- **Household work:** an excess of dust or pollution can reduce or alter the sensing capabilities of infrared devices. Attendance to household chores such as the cleaning of the carpet therefore might indirectly influence the sensor data. Another experience was when the householder was cleaning the wall clock, it slipped from their hands and hit the Phidget host board; one of the sensors lost its communication with the host board and, as a result, noisy data was recorded. We clearly need to account for unexpected events and to discover means for auto-recovering or informing about problems with the collection of sensing data.
- **Illumination levels:** the performance of infrared devices is affected by changes in illumination levels, and in our homes the levels of illumination can change when bulbs or lamps are turned on or off, and also when blinds, shades and curtains are used.

Activity at the centre of the room

The motion sensor installed in the centre of our room prototype is meant to identify activity around this central space. Exploration of its sensing capabilities (appendix B) showed the possibility of identifying not only activity but also direction of movement. However, this was not attempted in the prototype because of two drawbacks to using this particular sensing device to collect consistent information about direction of movement. One is associated with the short range of its sensing area: its angle of view is 10 degrees. When the motion sensor is installed at 192 cm, it gives us a sensing area of 33.6 cm diameter at the floor level and at approximately half this height its sensing area is reduced to 16 cm diameter. This seems to be a low sensing coverage when considering that around the motion sensor there is an unsensed space of approximately 150 cm. So what might be the likelihood of a child being active in the very centre of the room?

The second drawback is associated with the nature of the sensing device. This sensor uses differences in temperature between persons and their surroundings to detect motion. We found that either the surroundings or the body temperature itself might vary due to different circumstances. For instance, environmental temperature can vary according to the season of the year, or changes to the heating and ventilation systems, or even with the use of window curtains. With regard to changes of the person's temperature it might be associated with her/his level of activity; in our case we are also aware that the variations in young children's development might influence the collection of sensing data.

So far we have described how accounting for the social and individual aspects of domestic activity while exploring the installation of sensing technology can help to identify potential sensing limitations. This gives more realistic information that designers can use to identify the levels of context processing required to reduce sensing uncertainty, and to identify possibilities for the implementation of the system's collaboration.

The next section describes the implementation of the collaborative facilities to support parental tasks.

4.4 Collaboration and system adaptiveness

An important element within the proposed framework to design socially acceptable ubicomp systems is reducing the obtrusiveness of collaboration offered to the user (section 3.4). In the particular case of a ubicomp system to support childcare tasks, we should minimize interruptions to, for instance, the parent's attendance to household work and their direct nurturing activities. To that end, we have argued that systems should be flexible enough to allow users to adapt the system's collaboration as they wish. Moreover, the system's adaptation should be allowed at any level: sensing, context information processing and collaborative interactions.

For our domestic ubicomp systems we were not able to replicate the aware-room prototype in different homes to gain first-hand experience of adapting the system – the sensing layer in particular – in relation to different users' needs. Nevertheless, we argue that with ECT's flexibility to use existing or new software components, new technologies could have been readily integrated to adapt the system at the sensor level.

The following sections illustrate how users can interact with the PChCT to adapt the system's collaboration at the information processing level.

4.4.1 Adaptive collaboration – the PChCT

There are two different levels of adaptive collaboration suggested by our framework: collaborative services and collaboration delivery (section 3.4.1). In this section therefore we describe the different services and representation mechanisms implemented in the PChCT to allow users adapt the system's collaboration.

Adapting the system's collaboration is informed by considering on the one hand, the developmental stage of different children. We find that from birth to 6 years children develop different motor and psychological skills, e.g. children start rolling over, then crawling and then walking [Martorell et al, '06]. This natural development influences nurturing and caring needs [Spangler et al, '05], [Levy, '66]. On the other hand, adaptive collaboration should also help to minimize interruptions to parent's everyday activities.

The following sections will describe the different features and resources users can count with on the PChCT, but before that we formally introduce the PChCT design.

The Parent-Child Companion Tool prototype, PChCT, runs on a Dell Axim X30 PDA, and consists of three major elements: interfaces for collaboration, resources for hands-free collaboration and the interface to adapt collaboration. Figure 4.7 shows the general system architecture for the prototype and specifically its interaction with the PChCT. Communication between the host and the PChCT uses a client-server model.

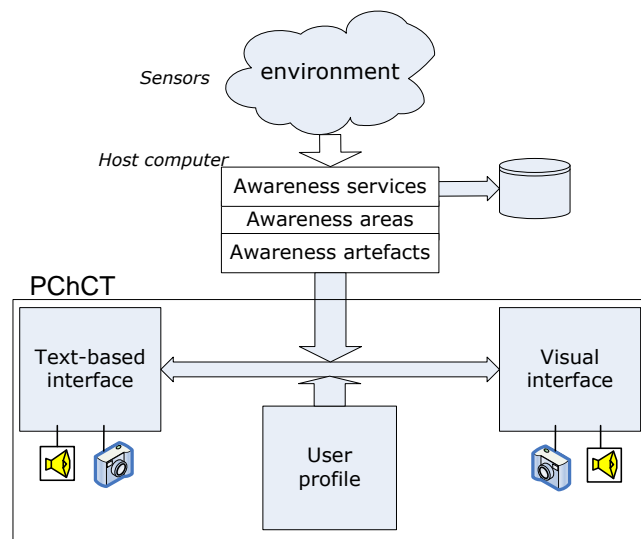


Figure 4.7 Overall communication between the PChCT and the host computer

The PChCT, developed in C# within Visual Studio 2005, uses two mechanisms to communicate with the host computer. The first is a TCP-IP socket that allows the PChCT to connect with the server that tracks events from the sensing layer (“Domestic Monitor Server”). The second is a HTTP service provided by a TOMCAT server. The communication from the PChCT to the “Domestic Monitor Server” is used to update the configuration for the system’s collaboration. Using the configuration of, for example, the awareness services the “Domestic Monitor Server” decides whether or not deliver reports to the PChCT. When activity is reported to the PChCT, it uses the sensor ID and its awareness reference to activate the spot and its correspondent awareness colour within the *space* interface and the message within the *events* interface. Should the user require the media interface, the PChCT communicates with the HTTP server to upload the picture of the room that

corresponds to the current event. These and other of the the PChCT facilities are described below.

4.4.1.1 Collaborative awareness services

Our framework suggests that the proactiveness of a system can be constrained if users are allowed to configure the degree of the system's collaboration (section 3.4.1.1). This section describes three collaboration approaches – awareness services, awareness areas and distances and awareness artefacts – that the PChCT has available for configuring the degree of the system's awareness.

Awareness services

This level of adaptation can be used by parents to reflect different needs for children's supervision. The three available sub-services, described below, could be associated with different levels of children's activity:

- **Monitoring in the background (digital album):** This service records to a digital file any activity occurring within the room but does not send any reports to the user interface. This activity history can be replayed at a later stage. One application of this service is the replaying of the room's images taken by the webcam to see how children have explored their home. Another scenario might include a child's accident, so parents can go to the digital records and identify the source of the child's pain.
- **Monitoring on-demand:** This service runs in the background but is ready for any request from the parent to know the child's recent activity. When the parent demands information about the child's activity the system delivers it to the PChCT.
- **Continuous monitoring (activity-aware):** This service allows a parent to monitor the child's activity on a continuous basis. To help the system in terms of intrusiveness the user is allowed to define one of three different levels of monitoring: general, alert and warning. These "awareness areas" are described in the next section and are defined in relation to the sensors' capabilities.

Awareness areas and distances

Using the continuous monitoring service might be seen as a collaborative approach that could monopolise parents' attention, and to avoid that we decided to take advantage of the distance sensors to create three awareness areas [Koile et al, '03]:

- **Warning activity:** Some parents might wish to be informed of situations when the child is too close to the artefact, which might represent a potential hazard, e.g. the fireplace. From the exploration with the distance sensing capabilities we know that the shortest reliable distance sensed by this device is about 10 cm. So the system could inform the parent with a warning message only when the child is as close as 10 cm from the artefact.
- **Alert activity:** Parents might be interested in an additional level of information before the issue of a warning proximity report. However, because different parents might want varying levels of alerting awareness, we decided that parents should be able to define the boundaries for the alert area.
- **General activity:** Parents might be interested in supervising any or all of the child's activities. In this case the system reports any whereabouts of the child, which in sensing terms represents any activity reported by augmented artefacts.

Figure 4.8 shows how the awareness areas inter-relate. We could observe that once the parent defines an alert distance the boundaries for the general and alert area are established. The general area extends from the alert distance to the maximum sensing distance (≈ 110 cm). The alert area is defined by the alert distance and the minimum sensing distance (≈ 10 cm). Observe also the presence of a sensibility parameter.

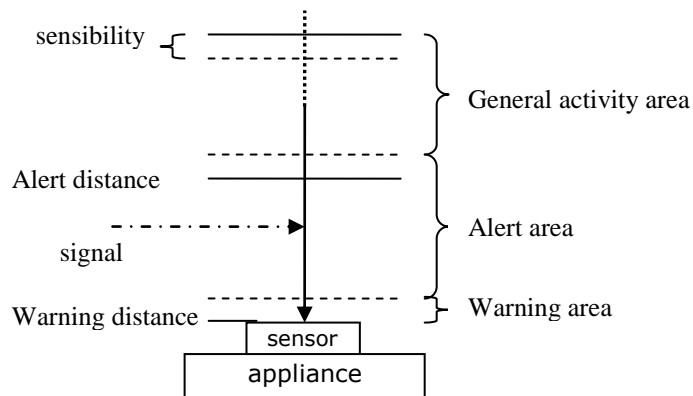


Figure 4.8 The aware parameters and the aware areas definition

The sensibility is a parameter established to help the system to constrain undesired variations from proximity sensor's performance. It acts as a fine grain control to reduce sensing uncertainty due, for example, to changes in the room's illumination. The existence of the sensibility parameter (dashed line) in any of the awareness areas helps, additionally, to establish a kind of threshold to identify transitions within or between these areas. Parents can configure the sensibility parameter if they are not interested in tracking changes of 1 cm for the child's activity, as it might be the case that the child is active in the same position – jumping or stretching. With the sensibility parameter, therefore, we allow the parent's involvement in constraining the system's proactiveness when noisy data is present.

Awareness artefacts

We have argued that if parents want to reduce the number of actively monitored artefacts, rather than physically uninstalling sensing points the system should allow these to be “removed” digitally. That is, the system allows parents to select or unselect artefacts, and the system uses these preferences when processing activity data, and to deliver collaboration. Information about the implementation of this approach is given in the next section.

4.4.1.2 Collaboration delivery

This section illustrates how different representation mechanisms are integrated within the Parent-Child Companion tool, PChCT, to convey collaboration (section 3.4.1.2).

The visual interface

A visual representation of the activity occurring within the context-aware room is available in PChCT. The *space* interface offers a graphical view of the room prototype layout in which it is possible to identify visually the child's activity. Each sensor-tagged artefact is shown attached to a small circle which is used to indicate when the child is close to the artefact, figure 4.9a.

To indicate when the child is in any of the awareness areas – general, alert or warning – the circle changes to a green, yellow or red colour. Because the centre of the room is considered as “safe”, activity around there is reported always in green.



a) space (room-view)

b) Events (text-based)

c) media

Figure 4.9 Collaborative interfaces

The text-based interface

The other available interface to report the child's activity is the *events* interface, figure 4.9b. This interface offers a short history of the child's activities. Whereas the *space* interface shows only the current activity the *events* interface allows parents to review, for example, how the child has made use of the home spaces and perhaps the type of activity. For instance, parents might see that the child has been sensed between the TV and the toy box, but that there is a predominant presence in front of the TV set, therefore, this information might suggest which TV programmes have interested the child.

The "Show" button can be seen in figure 4.9 within the *events* interface, just over the interface tabs. This can be used to open the media interface and the room's latest webcam image, figure 4.9c.

The media interface and the sound alerts

The media interface is an auxiliary interface that can be opened from the *space* or the *events* interfaces. It offers the latest room picture associated with the child's activity. From the *events* interface the user selects an event of interest and then asks the system to show the corresponding room picture. From the *space* interface, parents can click twice anywhere and the current room view is uploaded to the media interface. Once the media interface is loaded it will present the image for 5 seconds before returning the control to the interface from which the call was made.

The PChCT offers, in addition, sound alerts as part of any of the collaborative interfaces. Three different sounds are used to identify activity in the three awareness areas. This facility offers a hands-free service: if parents are undertaking household tasks then they do not need to watch the interfaces, but instead can easily identify activity from the sound emitted by the PChCT.

Finally, we present the “user-profile” interface (figure 4.10) that parents can interact with to configure the different levels of collaboration previously described.



Figure 4.10 The user profile interface

The bottom section is used to select any of the awareness services: digital-album, on-demand and continuous monitoring. Within this section, together with the awareness areas (general, alert and warning) there is the option to choose whether or not sound should be associated with the corresponding activity report. The middle section has the awareness parameters that the system uses to define the alert area and to manage sensing uncertainty. Finally, the top section is where parents can define which artefacts they want to be aware of.

In summary, we have described how the human and social context should be taken into account when designing and defining collaboration in a domestic ubicomp design. The family’s level of interpersonal awareness, together with behaviours of

the family members, such as idiosyncratic uses of spaces and artefacts, are two factors that particularly influenced the implementation of the system prototype. By taking into account both social and digital constraints we have arrived at a tool, the PChCT, which should be less intrusive in the parent's activities.

4.5 Conclusions

This chapter has presented the implementation of a ubicomp system which follows the design framework introduced in chapter three. We defined first the motivation underlying the design of a tool to support parental activities within the home. We then described the interactions between social and physical and social and digital contexts and their influence when defining the degree of support that the system should give to interpersonal awareness of parents and children.

The description of the framework's implementation focused on the design of two ubicomp prototypes, the context-aware room and the Parent-Child Companion Tool (PChCT). The context-aware room collects activity information from the room in which the child is active, whereas the PChCT is the mechanism through which parents interact with the system, for example, to adapt interaction. The implementation of the context-aware room prototype demonstrated how, despite having technology at hand, its accommodation within the home might not be straightforward. The selection of "what", "where" and "how" this pervasive technology might be integrated within living spaces was explored, bearing in mind the kind of support desired and social and individual aspects of the family's behaviour.

The definition and implementation of the PChCT's facilities was described taking into consideration again the behaviour of family members and the needs that parents might have for adapting the system's operation. The *space* and *events* interfaces are two different resources that parents might use to monitor the location, activity and status of the child. The *space* interface allows parents to have a rapid glance at the child's whereabouts, whereas the *events* interface offers more detailed information of how the child is using the home. If the level of the family's interpersonal awareness changes, parents can use the profile interface to adapt the system's collaboration to

suit the new circumstances. This approach to user interaction attempts to respect how parents choose to order their lives.

The level of the system's adaptation was considered in three areas: artefacts, activity and children's development. Each of these might be used to establish the level of collaboration needed by the user. For instance, parents can decide which artefacts should be used to report the child's whereabouts, or they can establish a level of proximity to those artefacts. They could also decide whether the child has developed his/her own self awareness.

Finally, the implementation of our framework to design a socially acceptable ubicomp experience has shown that it is possible to address the constraint of first, obtrusiveness with regard to the built space, and second, intrusiveness with regard to the parent's everyday activities.

The next chapters present two evaluations that reflect on the likely degree of social acceptance for the PChCT.

CHAPTER V

ACCEPTABILITY OF THE PARENT-CHILD COMPANION TOOL

5.1 Introduction

Chapter four described the implementation of the context-aware room and the Parent-Child Companion Tool (PChCT), to demonstrate how our framework, defined in chapter three, addresses the social-physical and the social-digital interactions to design more socially acceptable ubicomp experiences in real homes. This chapter describes the methods used to explore the social acceptance of ubicomp tools such as the PChCT, the results from which are presented in chapter six and seven.

Similarly to the “Technology Probes” approach [Hutchinson et al, ‘03] we make use of different evaluation methods – technology-probe-like prototype, field-testing, video-demonstration, surveys and interviews – to assess and understand parents’ appreciation of the usefulness of ubicomp technology. In particular we have used a questionnaire-based panel survey, and a hands-on usability study. The panel survey is a single session study in which the technology is introduced with a video demonstration; this demonstrates “how to use” and “what to expect from” the PChCT; then a questionnaire elicits users’ attitudes to the PChCT. The usability study comprises two sessions. In the first session parents are introduced to the activity-aware room; within the same session we collected data from the child’s activity. Within the second session parents use and explore the collaborative resources available from the PChCT, and a semi-structured interview helps to identify parents’ attitudes. The results of these two studies are combined to explore user acceptance and potential opportunities for the improvement of this type of ubicomp tool.

Section 5.2 describes the overall approach of the PChCT acceptability study. Section 5.3 covers the design and management of the panel survey study; its results are presented in chapter six. Section 5.4 deals with the design and management of the usability study; its results are presented in chapter seven. Finally, section 5.5 presents chapter conclusions regarding expected goals of the PChCT acceptability study.

5.2 Acceptability approach

We are using a bottom-up approach to explore parents' acceptance of the PChCT. As shown in figure 5.1, the acceptability approach combines two attitudinal studies: a panel survey and a usability study. The outcomes from the panel survey form the basis of the acceptability criteria. Outputs from the usability study are used to give additional detail and insight and thereby to assess the overall acceptability criteria. In other words, findings from both studies are used to identify the degree of acceptance of this type of ubicomp tool, which seeks a place in the user's everyday life.

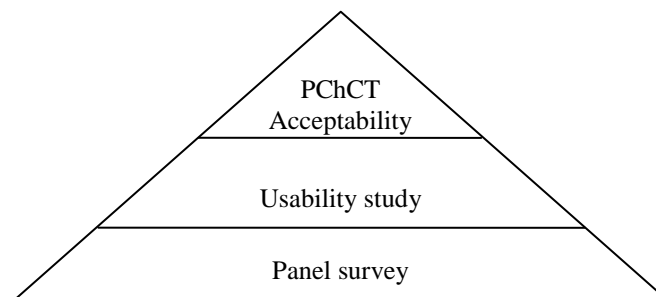


Figure 5.1 The PChCT acceptability study – a bottom-up approach

Below we define the individual aims of the panel and usability studies, while further detail of each study is given in sections 5.3 and 5.4 respectively.

The Panel Survey

This study explores the extent to which parents might consider a technological tool useful for helping with the childcare task in the home. We are using the benefits of group-administered surveys to get feedback from a larger number of respondents (twenty in this case). Results from this study should help us to understand how parents regard some of the constituent tasks when caring for young children in the home, and whether services offered by the PChCT tool might be seen as a useful resource to support them in this. We are interested, for instance, in the parent's perception of the possible existence and availability of this kind of tool and the potential use of such a tool.

The Usability Exploration

The usability study explores parents' perceptions when they are given practical experience of using the tool. The usability test of the PChCT helps us to study individual attitudes when experiencing the tool within the everyday environments in which the tool is expected to be used, i.e. the user's home. In other words, by mean

of the usability study we are allowing parents to identify the potential use of this tool in terms of, for instance, its effectiveness and pleasantness.

PChCT's acceptability

The overall aim is to identify to what extent parents might accept help from monitoring tools, in particular from the PChCT. The panel survey and usability test, each within its own context, will be used to assess each of the four research goals that we define here in relation to the PChCT's acceptability:

1. "The designed system addresses social demands to support domestic tasks"

We have argued in chapter I that little research has been focused on the support of mundane domestic tasks, and in chapter two we referred to some ethnographic work that shows in particular social demands for domestic support with childcare, for example. Consequently, we have proposed a ubicomp system that aims to support parental tasks in the home. Our first acceptability exploration therefore is to identify to what extent parents perceive that they might benefit from help with the childcare task. We suggest that the panel survey and usability study will help to answer the following specific research questions:

"To what extent are parents aware of children's activities?"

"To what extent would parents consider using a tool to monitor the child's activities?"

2. "The framework gives rise to a system which is socially appropriate"

As discussed in chapter four, we proposed a framework that offers a socially-informed design approach for ubicomp domestic tools. Designs are refined by considering the accommodation of technology and the degree of system collaboration together with user behaviour and preferences. That is, the framework should allow users to adapt the system to their individual needs at any time. We expect to assess this goal by exploring the following research question:

"To what extent do the system's interactive resources make parents feel they are participating in defining the system's collaboration?"

3. "The user-interface provides the collaborative context and resources required to support the identified social needs"

In the particular case of the PChCT, the user-interface was designed taking into account different social scenarios that led us to the implementation of what we believe is not only a friendly but also an informative resource that parents could find useful as part of the childcare task. In order to assess this goal we need to find a response to the research questions:

“To what extent do parents consider the PChCT’s collaborative resources to be acceptable for monitoring the child’s activities?”

“To what extent do parents consider the activity-aware service to be acceptable to help with the monitoring task?”

4. “This kind of domestic ubiquitous designs would be accepted and adopted”

If all of our previous goals have to some extent been met, then we would expect some degree of social acceptance of this kind of ubicomp domestic design; this is the upper level in our acceptability approach. Our research question is:

“To what extent would parents like to use the PChCT?”

Figure 5.2 shows how these six research questions fit together within the overall acceptability approach. This also indicates the main scope of the survey and usability studies.

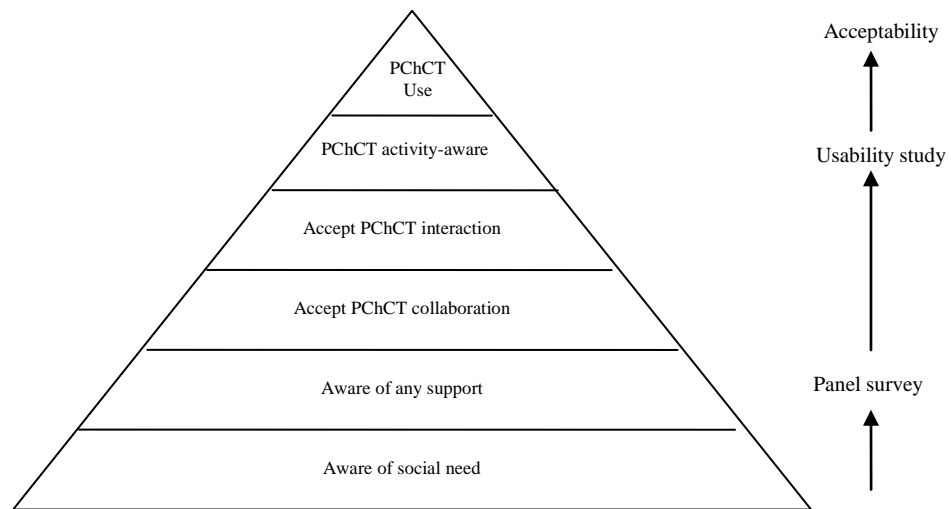


Figure 5.2 The acceptability approach and the particular research questions

The panel survey explores parents’ sensitivity to this type of ubicomp tool whereas the usability study elicits more specific responses to the PChCT. Thus, both studies provide complementary measures of the PChCT’s social acceptability. On the one hand, the usability study identifies attitudes from the direct experience of three parents with the PChCT tool; parents’ acceptability explorations are focused on the interactive and collaborative resources offered by the tool. On the other hand, the

panel survey collects feelings from twenty parents who have been introduced to the tool using a video demonstration, in which the focus is more on the parenting task and general attitudes to the PChCT system. Table 5-1, presents an overview of the panel and usability study's characteristics.

Subject	Panel	Usability
Presentation	Video	Print outs
Technical information	General	Specific
Hands-on session	No	Yes
Feedback	Questionnaire	Interview
Participants	20	3
Study time per participant	30 min	2 hrs

Table 5-1 Summary of the acceptability studies

Two important elements of the usability study are parents' perceptions of the PChCT's collaborative and interactive features, therefore, before describing in detail the design and management of the panel survey (section 5.3) and the design and management of the usability study (section 5.4), we introduce the scope of the PChCT's collaboration and interaction.

5.2.1 The PChCT's collaboration

Collaboration refers to the means by which the tool informs parents of their child's whereabouts. There are three different levels at which the PChCT collaborates with users: interfaces, presentation mechanisms and services. The "space" and "events" interfaces are used by the PChCT to report children's activity. These interfaces differ from each other mainly in the type of presentation mechanisms used to report activity: the space interface uses visual elements whereas the event interface uses text-based messages. Two additional resources to report collaboration includes sound and media. Services represent another level of collaboration. Users can use these to configure different levels of collaboration. Overall, we expect that parents might find the PChCT's collaboration to be useful to complement their childcare-related activities.

5.2.2 The PChCT's interaction

Interaction refers to the means by which parents participate to request and/or configure the PChCT's collaboration. One of the basic interactions is available for parents to request the picture of the room from which the child's activity is being reported. Another level of interaction is through the use of the "user profile" interface. In this interface there are some resources parents can use to adapt the

system's awareness, which also define the level of collaboration. User's interaction with the PChCT also includes concerns about the practical use of the tool – portability and size and dimensions of the PDA. In general, we expect that parents might perceive the PChCT's resources to adapt the system collaboration to be both useful and approachable.

An ideal parent response regarding the acceptance of a ubicomp tool such as the PChCT might be paraphrased as follows:

“As a parent there is often a need to supervise children's activities, and means for monitoring or recording the children's experiences would be welcome. In particular, the PChCT's features to report and show you visually the child's whereabouts and potentially risky activity would be useful when undertaking household tasks concurrently. In addition the PChCT allows the tool's collaboration to be adapted exactly as required. I would buy and use the PChCT if its was available”

5.3 Panel survey study

As introduced previously, we are using a group-administered questionnaire to survey social attitudes to ubicomp technologies such as the PChCT. We are exploring whether ubicomp support might be accepted to support parents' everyday activities. This section describes in detail the design and management of the panel survey.

5.3.1 The panel survey design

There are three important elements in the panel survey: gathering of participants, introduction of technology to parents and the questionnaire. In this section we present the survey design, which includes the building of a video demonstration and the design of a questionnaire.

5.3.1.1 The video presentation

The aim of the video presentation is not only to introduce the ubicomp system but also to set the context for the questionnaire session. The seven minute PChCT presentation includes information about the social issues informing the design of the tool as well as the available features that are offered for collaboration and interaction. The video starts with the social scenarios that were used to give support to the proposed framework and the PChCT design. We then present a general overview of the system features including the sensing technology and the whole system's

organization. In the middle of the video presentation we describe the interactive and collaborative features of the PChCT and a configuration example is used to show the use of the profile interface. The video presentation closes by demonstrating the use of the activity-aware service controlling each of the awareness levels (general-activity, alert-activity and warning-activity). Table 5-2 lists each of the features and resources used to introduce the PChCT tool to the parents. Here it is possible to see the time in seconds allocated to each of these features within the presentation.

Video section	Feature level 1	Feature level 2	Feature level 3	Time(sec)
Social support	Child’s accidents in the home			08.03
	Household time demands			06.56
	Child alone			04.59
System introduction	Overall aim			13.58
	Organization			12.70
	Collaborative and interactive aims			08.39
	Collaborative scenarios for parents			18.00
	Child’s activity-aware scenarios			13.05
Tool interaction and adaptation	Profile interface aim			18.05
	Profile interface intro			35.50
	Profile interface usage example	Activity-aware	Awareness levels	25.05
			Awareness distances	28.55
			Labelling stuff	07.01
			Visual representation	05.02
		On-demand and digital-album overview		17.20
	Media request			37.45
Tool collaboration	Intro			08.00
	Activity-aware usage	General activity		59.52
		Alert activity		60.20
		Warning activity		39.47
			Total time (7.03 min)	420.03

Table 5-2 The PChCT video presentation structure to the panel survey study

From table 5-2 we can identify that from the 7.03 min (420.03 seconds) presentation about 81% of this time (5.41 min or 341.02 sec), was used to introduce the interactive and collaborative mechanisms. That was in principle to give parents a vicarious experience of configuring and using the PChCT's features for monitoring, which we expected at the same time could allow parents to imagine their own use of such a tool.

The whole presentation is available in the form of a digital media in appendix C. The next section presents the design of the questionnaire, also available in appendix C.

5.3.1.2 The questionnaire design

The questionnaire was used to collect users' perceptions after the PChCT video demonstration. The questionnaire consists of five sections. Section one is used to present the objective and motivations underlying the research. Additionally, the importance of the parents' feedback and participation is appraised. Section two is used to record the age in years and months of the parent's child (or the youngest if they have more than one child). Section three is the basis for our acceptability measurement, and consists of twenty-two items ranked using a Likert scale of five points or degrees; from "strongly disagree" to "strongly agree". Section four is a modified five-points Likert scale, from "less-liked" to "more-liked", used to explore the extent to which parents liked some of the tool resources offered for collaboration. The final section consists of an open question in which parents are asked to give a final comment about the possible use of the PChCT tool. Table 5-3 summarizes the questionnaire sections.

Section	Description	No. Questions
Section 1 (intro)	Aim of "Can technology support parents?" survey	None
Section 2 (child)	Child's age	1 (OP)
Section 3 (main)	Parent's views considering PChCT useful to supervise/monitor children's activities	22 (LK)
Section 4 (likes)	Parent's likes of interfaces and services	9 (LK)
Section 5 (open)	Parent's opinion on the use of technology, the PChCT in particular, to monitor children's activities	1 (OP)

Table 5-3 The five sections of the "Can technology support parents?" questionnaire
OP-open question, LK-Likert scale

As mentioned above, the main questionnaire section will be used to explore the social acceptability of this type of ubicomp tool, which aims to support domestic activities. Questions within the main section cover different areas of the acceptability study described in the previous section. As shown in figure 5.3, these questions can be divided into six groups in order to analyse parents' attitudes to the PChCT. For instance, to achieve a sense of parents' awareness to children's activities (group G1) we used some scenario-based questions in which parents reflect on their knowledge about the child's whereabouts and growing up experiences. Other more specific questions were used to get a sense of, for example, the parents' understanding of the

PChCT's features such as the use of the awareness levels: general-activity, alert-activity and warning-activity.

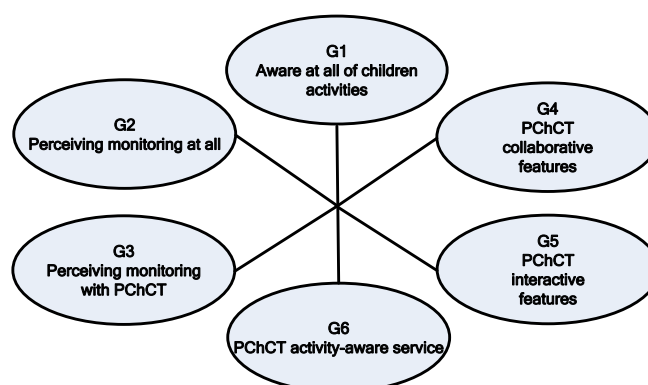


Figure 5.3 Question groups used on the main survey section

Questions within section four (likes/dislikes) measure the extent to which parents' like the different features available within the PDA user-interface: interfaces, services and elements such as sound and media.

5.3.2 The panel survey management

This section presents the execution of the panel study, which includes the selection of the setting, gathering of participants and the administering of the panel survey session.

The setting

The panel study was done in the Tender Loving Childcare setting, TLC. This nursery is situated at the University of Nottingham and provides care for children from the age of six weeks to five years. We decided to use a nursery setting to conduct our study because in this type of setting we can recruit a suitable range of participants. For instance, we can personally invite and gather participants with regard to the children's age of interest. The study was agreed by the TLC to be carried out during their funfair social activity. Drawing on the experience from the TLC's staff with the management of this type of event we adopted the approach of inviting one of the parents to participate in the study while either the other parent or one of the support staff was caring for the child enjoying the funfair.

The participants

With the permission granted for our panel study, a leaflet was produced and either personally handed to parents or placed in the children's backpacks in order to approach participants. The invitation (appendix C) contained information about the

study; its structure including the maximum number of participants; and information about an economic incentive after the completion of the study.

The invitation was open to any parent of a child of any age; we expected the children's age in a nursery setting to be from a few months up to five years. Our interest is not precisely in responses from children, but from parents with young children. The tool is designed to support the parental task in the home and, we are therefore interested in how parents perceived the tool's features for collaboration and interaction in the context of their own experiences of caring for their children. Table 5-4 shows the ages of the (youngest) children of our participants. To explain some of the table divisions, consider the groups 1-2 years and 2-3 years. Within the group 1-2 years there were three children aged 1, 1.2 and 1.4 years respectively. The sample for the 2-3 years children is six; children' ages are 2, 2.2, 2.3, 2.3, 2.5, 2.7 years respectively.

Group	Children's ages (years)					
Under one year	0.8			0.11		
One to under two years	1			1.2	1.4	
Two to under three years	2	2.2	2.3	2.3	2.5	2.7
Three to under four years	3	3	3	3.1	3.4	3.5
Four years and over	4.2			5.6		

Table 5-4 The children's ages – grouped by age

Administering the survey session

Participants were registered in two groups of ten parents each prior to the panel survey session, assembled over the period of one hour. The program for each of the two groups was the same: a short welcome and thank-you followed by the 7 min PChCT video demonstration and then the group-administered questionnaire. The questionnaire session, which followed immediately at the end of the video presentation, was opened with a thank you, general instructions about the questionnaire session and handing the questionnaire sheet to each of the participants. A final word of advice was given to remind participants to collect their economic incentive when handing back the answered questionnaire. The complete study lasted for thirty minutes.

5.4 Usability study

The usability study aims to explore the parents' perceptions and feelings of the collaborative and interactive features offered by the PChCT. To that end we record

the parents' experiences of using the PChCT tool and examine the extent to which this kind of ubicomp design can be accepted as a resource to support the parents' daily attendance to both housework and childcare.

To define the usability test a reference framework has to be established. There are two elements to be considered: what is to be measured and by what means measures will be collected.

In order to define the scope of what will be measured from the PChCT we draw on work done by Stanley [Stanley, '02] who suggests that a usability test should measure four functions: usefulness, ease of use/learning and pleasure in use. Similarly, Barnum [Barnum, '02] argues that a product's usability is the user's perception of the quality of the product. She says that ease of use, ease of learning, the product's usefulness and the user's satisfaction are the basis of usability.

We consider therefore that the PChCT should also be assessed in terms of usefulness and usability. Usefulness assesses whether the PChCT fulfils its purpose, whereas usability measures, for example, time and effort needed to accomplish a task.

Using the dictionary definition for usefulness, we have subdivided usefulness into two dimensions: practical worth and applicability. The framework used to explore the usefulness and the usability of the PChCT is then described in Table 5-5.

We can then define the usefulness of the PChCT:

"The PChCT's usefulness is defined by the worth and relevance of its resources to support and empower parents in parental tasks."

Worth and relevance require that the benefits of using or applying the tool are clear.

In the same way we can define the ideal usability of the PChCT:

"The accomplishment of monitoring tasks using the PChCT is straightforward and pleasurable, and simple to master."

Parents must feel confidence and enjoyment when they make use of the tool.

Usefulness	Practical worth	Having worth, merit, value to serve a purpose without elaboration
	Applicability	Relevance by virtue of being applicable to the matter at hand
Usability	Easy to use/learn	Posing no difficulty; free from worry, trouble
	Pleasant to use	Giving/affording pleasure or enjoyment; agreeable

Table 5-5 Usefulness and usability framework for the PChCT's usability

Having defined the aspects of usability to be considered, we now define the approach to be taken in the usability study.

5.4.1 The usability study design

We have argued that the usability study aims to identify the usefulness and usability of the PChCT. In this section we define the approach used to collect these measures. In order to create a realistic environment in which to undergo the user-centred experience, our usability design consists of two independent but interrelated elements: an activity monitoring session and a usability test session. The former collects information about the parent and child's activity within the activity-aware room prototype. The latter uses this data to give parents an individualized experience with the PDA user-interface. These processes are independent because they have different goals and they are therefore administered differently. However, they are interrelated because the outcomes from the first provide the data which is used as input to the second.

By combining these two elements we expected to offer users a more pleasant and realistic experience within the usability study. For instance, we are not only bringing the usability experience to the user's own home but also offering a personal experience because the information the PChCT uses to collaborate with the parent is collected from their own child. By doing this, we believe, the parents might feel more comfortable using and interacting with the tool and might more easily identify and understand the approaches used by the tool to deliver collaboration.

Activity monitoring session	Usability session
<ul style="list-style-type: none"> - Gather test users - Introduce ubicomp system - Collect child's activity - Process child's activity 	<ul style="list-style-type: none"> - Introduce parents to the PDA user-interface - Collect feelings from the hands-on session - Collect feedback from the interview session

Table 5-6 The usability study design approach

Table 5-6 summarizes the overall aims of the activity monitoring session and the usability session, but further information about the structure and management of these two sessions is given in the following sections.

5.4.2 The activity-monitoring session

One important element within our approach to the PChCT usability study is the collection of activity-data from children. This information should resemble a small but valuable piece of the daily parent-child interaction, and we argue that this might make a considerable difference to parents' feelings. For instance, we expect that parents might have a clearer perception of the PChCT's usefulness if the tool uses their own child's activity to report to parents instead of using laboratory data to simulate children's activities.

The activity-aware room prototype is used to collect sensor data from children's activity. Thus, the management of the data collection session must, for example, carefully address the recruiting of test users; the value of parents' time is well recognized as is the likely difficulty in engaging them in research studies. Additional elements that must be taken into account are the environmental setting in which children's activity is collected and the processing of the gathered information.

The next section describes in more detail the approach used to manage the activity collection sessions.

5.4.2.1 Data collection management

This includes setting up the physical location that will be used as the "stage" for the test users' activities; the selection of the parent-child participants; and the mechanisms used to record their activity. The administering of this process is of high importance because we are addressing the portability problems of ubicomp technology (at least of our activity-aware room prototype). We found that because of the sensing technology and social constraints, the simple reproduction of the aware-room prototype within different houses was almost impossible. Therefore, we needed to find a fixed setting that satisfied our requirements, for example, to engage participants smoothly. We now describe how each component of the data collection process is administered.

The setting

As previously mentioned, to carry out the activity monitoring session the activity-aware room prototype was used. Activities which prepare the prototype room to host

user tests include, for example, the verification that the sensing technology and its communication with the host computer are both working. Once system verification is done, it is left running until the end of the test session. A box of toys expected to be of interest to the children, was also prepared.

Test users

Three parents were invited to bring their children to spend a period of time taking part in ordinary daily activities within the activity-aware room. The parents were selected from friends of the host (the author's wife), because we were aware that if children were not familiar with the host home environment they could be inhibited, and their activity limited as a result. We expected that children who are accustomed to visiting the host home would feel confident with the surroundings and so record richer and more representative activity. Table 5-7 lists the parent-child participants and general information about their daily activities.

The activity-monitoring session

As with recruitment, the session collecting children's activity also required specific attention. It was important to obtain parents' agreement to a date for the collection of children's activities. In this case, they were planned for Saturday mornings and lasted for no more than two hours. During these two hours the child was encouraged to play, explore or watch television within the activity-aware prototype while the mother was most of the time in a different room engaged with the host. Any activity around the sensing points was then recorded and saved to a log file.

Parent	Activity other than housework	Child's age (years)	Private childcare
1	- Works halftime four days of the week - the child attends the nursery half a day from Monday to Friday	3.5	Half a day the whole week
2	- works halftime the whole week - the child attends the nursery half a day three days a week	1.11	Two half days
3	- works fulltime two days a week - childcare is done by parents or grandparents at their respective house	2.4	Full time whole week

Table 5-7 Parent-child characteristics

The orchestration of these elements can be summarized as:

“The system is switched on an hour before the parent and child arrive. When the parent and child arrive a short welcome is given. Information regarding the

research is then offered and an explanation of the system is given. Particular attention is given to the sensing technology's location and the way it is used to monitor the child's activities, in order to make it clear to parents that no hazards are present within the session. Following this, parents are given a simple guideline: as far as possible the parent should try to be in a different room from the child. From that point, the child's activities are recorded for two hours. At the end of the session parents are thanked and informed that data will be processed and once it is completed they will be contacted to agree a date to carry out the PChCT usability session.”

5.4.2.2 Data processing management

At the beginning of this chapter we defined the scope of the acceptability study in terms of the PChCT tool without including the context-aware room prototype (CARoom). This confinement of the acceptability study is mainly due to the practical difficulties of replicating the activity-aware room within different houses; which limited our explorations for the everyday use of the PChCT tool across different users and user's needs.

Considering the constrained context for the evaluation of the CARoom and that the hands-on experience within the usability study is also limited to a 30 minutes session, we must maximize the user's experience with the PChCT. This implies the minimization of uncertain collaboration from the CARoom (appendix B). If “noise” from the CARoom sensing data is not “controlled”, we believe, the parent perceptions of the usefulness of the PChCT – and to some extent of the system – might be seen affected. For instance, consider the situation in which the system interrupts the parent when she is directly nurturing the child.

To ensure that a reduced level of uncertain activity from the server side reaches the PDA user-interface, two data processing stages are used – cleaning and filtering – the aims of which are now explained.

The cleaning stage

Though there are different family contexts worth to explore with supportive computing technology - parents with children of different age and stage of

development, visitors, family party and so on, the current state of our system prototype aims exploring the domestic context of parents with one child. This cleaning stage then is used to remove data that does not belong to either the parent or the child activity. We noted that the system is sensing activity before and after the activity collection session. This extra information can include activity from the host and guest children. This “noise” activity can potentially overwhelm parents with time demanding and obtrusive issues; therefore, this out-of-context activity is removed. Figure 5.4 shows the total number of activity events before (left) and after (right) the cleaning of “noisy” data for each of the log files.

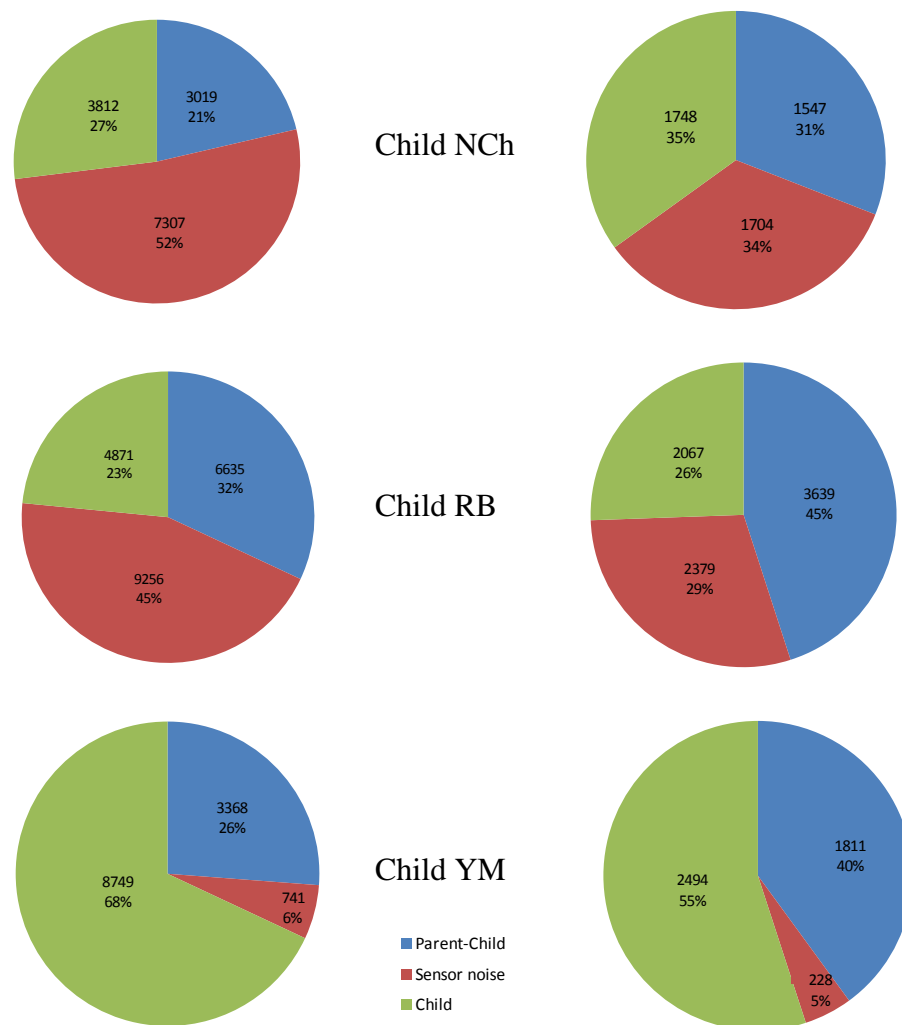


Figure 5.4 Activity data is processed to reduce ambiguous collaboration from the CARoom. Left – original source. Right – cleaned data.

The classification of these events was done through the reviewing of the images taken by the webcam, which is installed in one of the corners of the CARoom, during

the two hours of each of the parent-child activity. The presence of the parent and/or the child is indicated by the “Parent-Child” or “Child” event. The “Sensor noise” event indicates that either the sensor reports environmental noise (discussed in appendix B), or that a clear identification of the presence of a person within the room is not possible. The lack of view of the participant activity within the CARoom is due to webcam angle of view (fig 5.5).

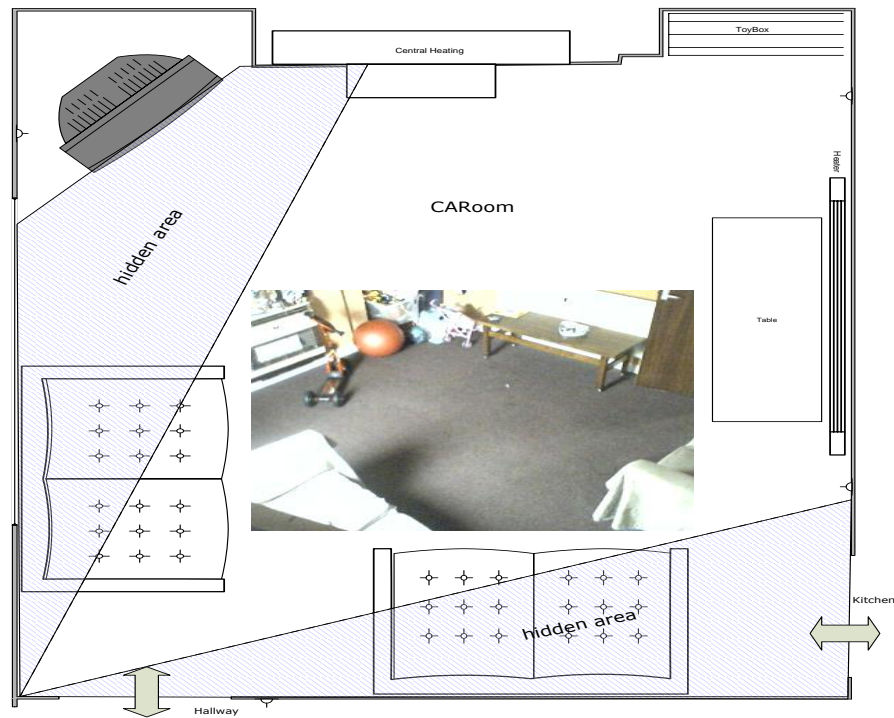


Figure 5.5 Angle of view for the CARoom

The filtering stage

The filtering stage is also used to maximize the parent’s experience with the PChCT. We have argued that our initial explorations with the sensors installed on the doors showed a likelihood of 90% to identify if the parent or the child goes into the activity-aware room (appendix B). However, from the participants’ data activity we realized that a greater rate of errors is present. These uncertain events from the door activity, we believe, is due to the “unusual” activity at the boundaries that connect the kitchen and the living rooms, for instance. This “unusual” activity might be associated to the guest activity. We assume that the guest participant stood on the door’s frame to keep an eye on her child and to maintain communication with the host parent. Table 5-8 shows true and false result events of a classification test for the door activity.

Door events	Kitchen door			Hallway door		
	Total	True	False	total	True	False
Parent NCh	26	16	10	10	6	4
Parent RB	78	29	47	17	9	8
Parent YM	38	25	18	49	23	26

Table 5-8 Classification of entry and exit events from parent's activity

For each door the column “Total” represents the number of entrée and exit events as classified by the system. Column “True” gives the number of events that were correctly identified from the available image from the CARoom. Column “False” gives the events that were incorrectly classified, e.g. entrée instead of exit. False events also include those for which it is not possible to strongly argue that these had occurred. For instance, we found events in which the parent apparently moves from the kitchen to the CARoom but she never showed up within the room, and after few milliseconds an exit event occurs; is it the parent within the hidden area? Did she really exit the room?

Thus because the guest behaviour seems to reduce the reliability for the classification of the door's activity, we decide to remove the parent activity. That is, only child activity will be allowed to reach the PChCT.

Reviewing the goals of the usability study we argue that the filtering task is crucial within the data processing stage. In particular, we argue that the end-user experience should be ideally error-free. The tool's services are designed to support the social attendance of the childcare task and, therefore, all technicalities behind the system performance should be transparent to the user. In this context, we can assume that the system is able to detect when the parent is in a different room by applying the filtering process to the activity data. This allows us to focus the parents' study to the usefulness of the overall system's aim (CARoom and PChCT) to collaborate with the monitoring of the potentially risky child activity.

After the preparation of the activity data, this is ready to be replayed within the PChCT, within the usability experience session, which we present next.

5.4.3 The usability experience session

This section describes the approach used for the usability experience. As pointed out in section 5.4, the aim of the usability test is the collection of users' feelings and attitudes through, in this case, real use of the PChCT. The design of this session includes the strategy used to collect users' feedback and the administering of the usability experience, which includes re-recruitment of users and the environmental setting.

5.4.3.1 The usability test structure

In this section we define the approach used to perform the usability test. The first element to consider is the definition of the context under which the usability test is carried out. The work of [Frokjær, Hornbæk, '05], suggests that usability testing should consist of two elements: the interaction section and the interpretation section. The interaction section allows the identification of the user's feelings while interacting with the artefact. The interpretation section is intended to help the user to abstract from their experience in using the artefact.

For the PChCT's usability study an interactive and a feedback section are included, but, additionally, we include an introductory section, similar to the "warmth" section named by Carter [Carter, '07]. The introductory section sets the context for parents of the acceptability study. This section updates parents on the development of the system design, introduced to them in the activity monitoring session, and introduces the PDA user-interface as the component designed to collaborate with them.

Section	Task description
Video	Presents an overall panorama of the social aspects supporting the PChCT design and a brief demonstration of how the tool could be used to monitor a child's activity.
Introduction	Offers an overall scenario of a ubicomp domestic system and introduces the PChCT PDA user-interface resources including technical aspects underlying the awareness facilities, for example, the aware distances.
Hands-on	Gives parents the opportunity to use the PChCT PDA user interface to explore its collaborative and interactive resources.
Interview	Collects information about parents' feelings, perceptions and attitudes from their experience with the PChCT tool.

Table 5-9 Summary of sections of the usability experience session

Table 5-9 summarizes what is covered within each of the usability experience sections, and in the following sections, we offer a more detailed picture of the components of the usability test experience.

The introductory section.

It has been stated that the introductory section aims to update the parent with information about the research, but this is also used to introduce the PDA user-interface features and resources, including details of the awareness parameters such as the aware distances. We consider this explanation of the PChCT's awareness parameters as a very important introductory element, because these technical elements define to a great extent the system's collaboration. To support the explanation of these technical aspects of the PChCT we use visual elements including print outs and sketches to engage parents with this information. Additionally, we use the PChCT interfaces to complement the theory about the awareness configuration. For instance, when information is given about the aware distance parameters the tool itself is used to demonstrate how the configuration of these parameters can be done and what the resulting changes are in the tool collaboration. Figure 5.6 shows one of the sketches and figure 5.7 one of the visual representations used to explain the aware distance concepts.

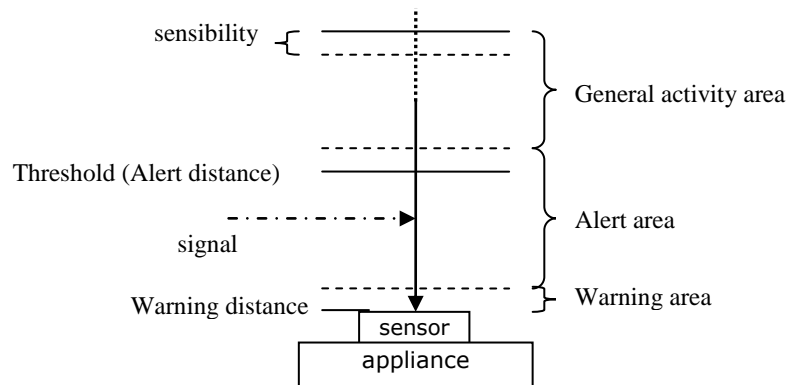


Figure 5.6 Explaining underlying concepts of aware distances and aware areas

Topics within the introductory session that refer specifically to the PDA user interface are: introducing the PChCT, its interfaces, and information resources and interaction capabilities.

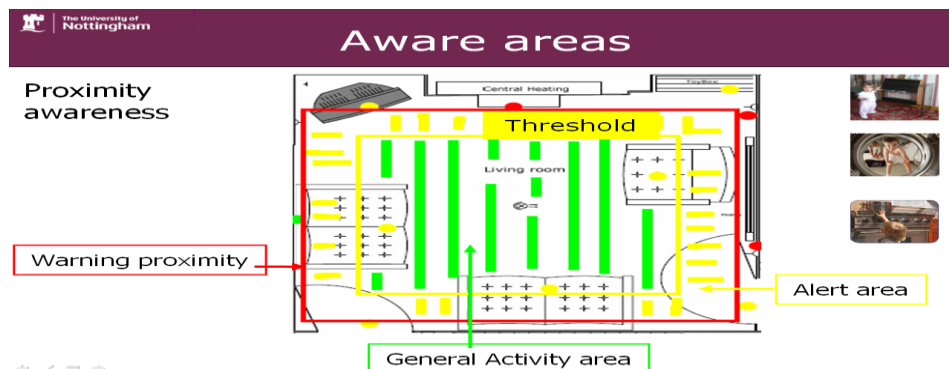


Figure 5.7 Print-out used to support awareness parameter configuration

The hands-on experience section.

Within this section parents use the PChCT tool. The hands-on section is a free time slot given to parents to explore independently features and resources that the PChCT has available for collaboration and interaction. Preliminary information given within the introductory section can be reinforced here with, for example, the configuration of awareness parameters to adapt the system's collaboration. Some of the expected outcomes from this section include:

1. Parents' reaction (e.g. pleasure or displeasure) to the reception of reports about their children's experiences from the PChCT.
2. Applicability of the PChCT monitoring tool to their everyday activities.
3. Parents' feelings about using the interactive resources to configure and participate with the system's collaboration.
4. Parents' perception of the PChCT as a supportive tool when caring their children in the home.

In general, the hands-on section helps to explore how social contexts might influence the parents' attitudes and thereby their acceptance to this type of ubicomp tool proposed to support everyday life.

The interview section

This section elicits parents' feelings after their experience with the PChCT. We are using an interview as the main mechanism to collect feedback from parents; however, we use notes taken from the hands-on experience to complement our observations. The interview section aims to identify the extent to which parents' consider that this kind of ubiquitous domestic design might be useful to support their everyday activities such as parenting.

To explore the parents' responses to the PChCT we use a guideline to conduct the interview; this is the interview section within our usability script (appendix D). Three broad aspects are being evaluated within the interview section: parents' general feelings about using the PChCT tool; parents' acceptance of the tool's collaboration to support them when looking after their children in the home; and parents' feelings about adapting the system's collaboration to their individual needs.

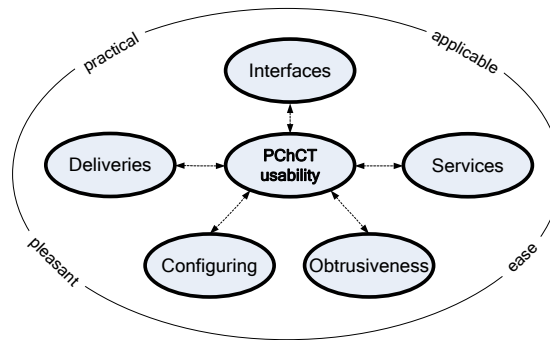


Figure 5.8 Mapping usability factors to PChCT

These elements are mapped to the four usability aspects – practical use, applicability, ease of use and pleasure – to evaluate the acceptability of the PChCT monitoring tool. That is, these four usability elements are used to explore the acceptance of each of the tool features, as shown in figure 5.8. There we also note that the interfaces, deliveries (presentation mechanisms) and services are the collaborative resources of the PChCT, whereas configuring and obtrusiveness aspects reflect the interactive features. It must be said, however, that an exploration of collaborative services includes the user interaction to configure these resources, e.g. exploring parents’ attitudes to the use of the activity-aware service implies asking for feelings about, for instance, configuring awareness distances.

The table 5-10 presents some of the aspects evaluated within the interview section.

Usability	PChCT measurement
Usefulness	<ul style="list-style-type: none"> • Are interfaces useful? • Is the collaborative approach applicable? • Is the approach offered for interaction of practical worth? • Which of the resources offered to monitor children might have limited use? • Is there any social benefit that might be foreseen with the use of aware services? • Is there something that should be integrated to improve the PChCT tool?
Usability	<ul style="list-style-type: none"> • Is there anything troublesome with the use of the PChCT tool? • How difficult might be its use within everyday activities? • Is there something that might be considered pleasant to use? • How approachable is the use of the aware services? • Are there any resource that should be modified to reduce complexities?

Table 5-10 PChCT measurements within the interview session

Having shown the structure of the PChCT experience section, we describe next how this part of the usability study was conducted.

5.4.3.2 The usability test management

In this section we present the process underlying the conduct of the PChCT’s usability experience, which includes the location selected to undergo the study and

the practical aspects of the study itself. Regarding the location, we have mentioned that the parent's own home was preferred for the usability experience. However, there was an exception: one of the parents suggested that the usability experience session should be done in a workplace setting rather than the parent's home.

The practical process, which is presented next, considers the engagement of participants and the administration of the usability session.

Practicalities of participation

- a) Approaching the participants: parents who took part in the activity-monitoring data collection, were again invited to participate. We discussed with them the planned context of the study, which included their agreement to two constraints. The first was to consent, if possible, to their child not being present. That is, parents were asked to arrange two hours of external care for their children. If that were possible, then we could reduce the distraction during the study because the parent would be less worried about attending to the child's activities and more focused on testing the tool's usefulness. The second constraint was that the parent agrees to be video-recorded all of the time. We must inform parents about the way they will be observed. For example, during the hands-on period parents are asked to walk around their home using the tool while the observer follows them recording their experiences with the tool.
- b) Participants: two of the three parents that participated within the activity-monitoring session were finally reached to complete the usability experience. It was not possible to agree a date with the third parent. We were able to find a replacement, but the context of her experience was slightly different, as discussed in the next paragraph.
- c) The replacement participant: the first element that distinguishes this participant is that the data to be used and replayed with the PDA user interface does not belong to this parent's child. However, we could argue that this might not affect the usability session unduly because this parent's child is only 6 months old (not yet mobile). On the contrary, it might help to give the parent a better understanding if they consider that in the forthcoming months the scenarios presented within the tool could be part of their parental experiences.

The second element that distinguishes this participant is that this was her first encounter with ubicomp research. It should be remembered that the other participants had been sensitized and introduced to the whole system's architecture in the data collection session, so the study for this parent was slightly modified; we included the PChCT video demonstration to sensitize this parent.

The third factor that makes this participant different is that she decided to undertake the study in her husband's workplace rather than in the privacy of her house, and both the parent and the child were present. Although the child was being cared for by her father, they were most of the time present in the study. This added some environmental noise to the study because the mother was from time to time keeping an eye on the child. This event indirectly affected the time planned for the study.

Parent	Activity other than housework and childcare	Child's age (years)
YM	- Works halftime four days of the week - the child attends the nursery half a day from Monday to Friday	3.10
RB	- works halftime the whole week - the child attends the nursery half a day three days a week	2.4
ML	- works fulltime two days a week - childcare is done by parents or grandparents at their respective houses	0.6

Table 5-11 The test users who were finally engaged

Table 5-11 lists information about activity and childcare management for the three parents who were finally engaged to the usability experience session.

Administering the usability test session

We have already pointed out how valuable time is for parents. So the management of time during the usability experience session is of high importance. We must bear in mind that parents made arrangements not only to allow time for the study but also arranged childcare in order to attend the study. We must remember, too, that the usability test session was adapted for the replacement participant. This section therefore presents the two approaches, home-session (for the original participants) and laboratory-session (for the replacement participant), used for the usability experience.

Home session: upon arriving at the parent's house we thanked the participant and chatted with them as an icebreaker while setting up the video camera. Once this was done and the parent was ready, we began with the introductory section: information about how the child's activity was processed, the system-architecture and the introduction of the PDA user-interface. We then moved to the hands-on section in which parents make an initial exploration of the PChCT's resources; parents were invited to play with some of the PChCT concepts reviewed in the introductory section. After this, they were asked to walk around the home using the tool – upstairs and in the kitchen, for example. There was no time limit: they used the tool, walked around the home, and stopped the session as they so decided. This was followed by the interview section. Finally, parents signed to mark the study's completion and received their economic incentive.

Laboratory-session: a laboratory space was arranged and the video camera for recording the study was positioned. When the parent participants arrived, they were welcomed and thanked. This was followed by a short briefing section about the research and the aims of the usability study. To complement information about the research we made use of the PChCT video demonstration. We believe that this additional material could help situate the parent within the research context. After the video section, we replicated the introductory, hands-on and interview sections as conducted with the other parents. However, some information from the introductory section was omitted, partly, because this parent had requested a reduced time study. We were therefore more interested in the hands-on and the interview coverage than with the introductory section. Some of the introductory information in any case appears in the video demonstration. The hands-on section was adapted: in the home-session parents walked around the home; this cannot be replaced in a laboratory study. However, the time assigned to this section was almost the same as that for the home-sessions. We were closely following this parent and supporting her use of the PChCT resources. Finally, after the interview section, the parent signed to mark the end of the study and received her economic incentive.

Table 5-12 is a summary to the usability test management to the three parents. We can see the differences in time allocated to each study. For instance, it can be seen that the time used by parent ML, the replacement participant, is approximately 25

minutes less compared with the study time of the other parents. However, despite these differences in the time, we believe the knowledge and experience gained from these social studies is rewarding.

Parent	Child's age (years)	Place to study	Usability experience time intervals (min)	
			Sessions	Time (min)
YM	3.10	Parent's home	Introduction	20.00
			Hands-on	15.00
			Interview	56.57
RB	2.4	Parent's home	Introduction	33.00
			Hands-on	17.40
			Interview	40.29
ML	0.6	Laboratory	Video	7.00
			Introduction	8.00
			Hands-on	14.00
			Interview	36.34

Table 5-12 Usability experience management

5.5 Chapter conclusions

In this chapter we presented the design and management of the PChCT's acceptability study. Two approaches were combined to support the PChCT acceptability study: a panel survey and a usability study.

A panel survey was designed to explore parents' attitudes using a group-administered questionnaire. The panel survey gathered the attitudes of twenty parents to the PChCT in the TLC nursery setting. We were thus able to cover the span of children's ages (from newborn to five years) that the PChCT is aiming to support. To provide parents with background to the survey a 7 minute video demonstration of the PChCT features was given before the questionnaire.

A usability study was designed to complement outcomes from the panel survey with more detailed experiences of the PChCT. The structure of the usability study included two sessions. The first session, activity-monitoring, was used to collect child activity data from the context-aware room prototype. Three parent-child pairs were invited to participate. The second session, usability experience, used data collected in the first session to replay the child's activities and to offer a hands-on

experience to parents of the PChCT. This session allowed parents to see in action some of the features that the PChCT offers for collaboration and interaction.

Results from each of these acceptability studies is presented in chapter six and chapter seven, respectively.

CHAPTER VI

PANEL SURVEY RESULTS

In chapter five we presented the design and management of two user studies: a panel survey and a usability study. The panel survey consisted of a video demonstration of the PChCT features and a questionnaire. The panel survey's results help us to understand overall perceptions of ubicomp tools such as the PChCT, which might help with parental activities. This chapter explores potential end-user attitudes to the PChCT and social factors that might influence its acceptance.

Section 6.1 describes the analysis approach used to explore parental attitudes from the survey questionnaire. Section 6.2 contrasts parents' attitudes to two issues: the parents' perceptions of the need for a tool for childcare monitoring; and parents' attitudes to the PChCT in particular as a resource that might complement the supervision of children in the home. Section 6.3 breaks down the results analysis with reference to the six scale groups defined in the previous chapter. Section 6.4 discusses individual feelings and attitudes to monitoring tools in general and the PChCT in particular. Finally, section 6.5 offers the chapter conclusions.

6.1 Survey analysis approach

This section describes the approach used to explore parental attitudes to the PChCT, from the "Can technology support parents?" survey questionnaire. This exploration is done at three levels. Level one contrasts the results from three factors: parents' awareness of children's activities (G1), parents' attitudes to monitoring tools (G2) and parents' perceptions of the PChCT's usefulness (G3-G6); this level helps to identify overall perceptions of ubicomp tools as a means to support childcare tasks in the home. Level two explores feelings and attitudes to PChCT resources available to support parental activities: the six scale groups (G1-G6) are explored individually to observe parents' preferences, looking in particular for social or technical elements that might have influenced low scores. For these two levels we explore attitudes from categories (G1 to G6), individual questions and children's age groups. The third level of analysis discusses social factors that might be associated with questions with negative responses. Table 6-1 summarizes the three levels of exploration.

Analysis level	Groups/scales or items	Description
Level 1 general results	G1,G2,G36 (G3-G6) Child-age-based groups	The extent to which parents' feelings persist from social to technology-based contexts.
Level 2 analysis of categories	G1,G2,G3,G4,G5,G6 Child-age-based groups	Identification of factors/elements influencing attitudes against the technology-based tools.
Level 3	Questions/parents	What social contexts might influence parents' feelings against this type of ubicomp tools?

Table 6-1 Levels of analysis to explore parents' attitudes from the panel survey

Throughout the chapter we use scores associated with the five points Likert scale – “Strongly Disagree” (1), “Disagree” (2), “Undecided” (3), “Agree” (4) and “Strongly Agree” (5) – to examine the response distributions to the question group or child-age group under exploration; and also a three sub-groups of the Likert scale – “Broadly Disagree”, “Undecided” and “Broadly Agree” – to get a more general perception of the parents' attitudes. “Broadly Disagree” (BDA) groups “Disagree” and “Strongly Disagree” responses; “Broadly Agree” (BAG) groups “Agree” and “Strongly Agree” scores. UN represents “undecided” responses.

Before analysing the panel survey responses, we present information to be used throughout the whole chapter. Table 6-2 shows the sample population grouped by children's age. For instance, within the “Two-to-three years” group there are 6 parents with children aged 2, 2.2, 2.3, 2.3, 2.5 and 2.7 years

Group	Children's ages (years)					
Under one year	0.8			0.11		
One-to-two years	1		1.2		1.4	
Two-to-three years	2	2.2	2.3	2.3	2.5	2.7
Three-to-four years	3	3	3	3.1	3.4	3.5
Four years and over	4.2			5.6		

Table 6-2 Sample population grouped by children's age *

* Total=19, missing=1

One parent failed to complete the child's age section in the questionnaire. When exploring attitudes by children's age groups we will therefore always have this data missing; however, this will not affect our analysis within the categories or individual scores.

Table 6-3 shows the six scale categories used to explore parents' feelings and attitudes. These groups come from the “main” section of our survey questionnaire. However, during the exploration of parents' attitudes from these responses we will make use of the “likes” and “close” survey sections to give extra support to the findings from the “main” survey section.

Group	Attitude measured	Questionnaire items
G1	Aware of child's activity	1,2,4,7,13
G2	Use of a tool for monitoring	3,8,15
G3	PChCT as a monitoring tool	5,6,9,18
G4	PChCT collaborative feature	10,11,17,20
G5	PChCT interactive features	21,22
G6	PChCT activity-aware collaboration	12,14,16,19

Table 6-3 Question categories or scales and their measures

6.2 General results

In this section we explore attitudes in two broad areas: felt needs for support with childcare in the home, and parents' perceptions of using the PChCT to help with childcare. To this end, we explore scores given to the G1, G2 and G36 question groups. G1 aims to elicit parents' thoughts about awareness and childcare, but it also helps to prepare parents for the survey of how technology might support them with childcare-related tasks, G2. G36 explores, in particular, parents' perceptions of the PChCT's usefulness. G36 is a super-group combining the G3, G4, G5 and G6 groups, which in general measures attitudes to the PChCT's facilities. The combination of G36 is additionally supported by a Cronbach's alpha test, the coefficient of reliability of which was of 0.837. This parameter, which indicates the consistency of a group, or scale or questions, supports the use of G36 as a single scale or group.

The first exploration focuses on how parents' attitudes change from social to technology-based scenarios, G1 to G36. Responses to each of these groups are explored using the statistical distributions of their overall scores. In addition, we use some measures of central tendency and dispersion for the Likert scales in order to highlight particular findings.

Figure 6.1 and table 6-4 present parents' responses to G1, G2 and G36. The first observation is that the least positive perception is for group G36. Also, we identify G1 with the highest variance, which was unexpected. As previously stated, G1 invites parents to consider the different circumstances in which they might need to be aware of their children; however, it seems there are other factors in these responses, which we will explore in section 6.3.

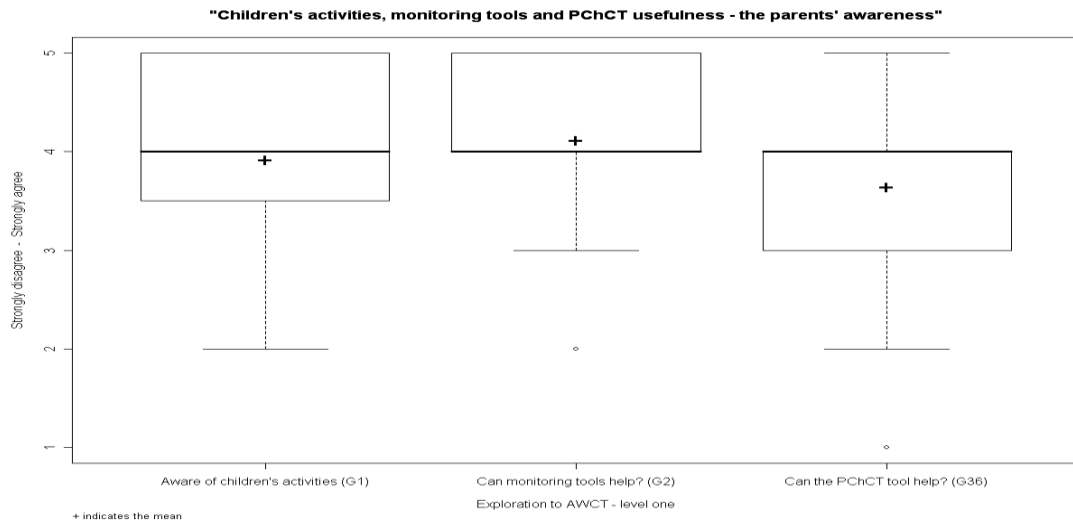


Figure 6.1 Response distribution when moving from social to technology-based contexts

Nevertheless, from figure 6.1, we could argue that parents consider that ubicomp technology might be of help, but with regard to the usefulness of the PChCT in particular parents prefer to be cautious in their opinions. In other words, it seems that attitudes depend on the use of technology, with group G36 having the lowest scores.

If we review basic statistics for the G1, G2 and G36 scales, depicted in table 6-4, we observe that greater uncertainty arises when the PChCT is presented as the tool that might support childcare.

Attitude	Mean	Var	SD	N	BDA	UN	BAG
Aware of children's activities (G1)	3.92	0.9834	0.9916	100	14%	11%	75%
Can monitoring tools help? (G2)	4.11	0.4511	0.6717	59	2%	12%	86%
Can the PChCT tool help? (G36)	3.64	0.6120	0.7823	279	8%	28%	64%

Table 6-4 Densities and attitude variability – social to technology-based contexts

Again, although the dispersion of G1 deserves our attention we will reserve its analysis for section 6.3. Thus, from table 6-4 we observe that parents have a positive perception of ubicomp tools usefulness (86%), but are less positive if they consider the PChCT (64%).

To give an early view of parents' overall perceptions of some of the PChCT's features, in table 6-5 we present basic statistics to scores given within the "likes" section of the survey questionnaire. That section explores whether parents like the PChCT features offered for collaboration, introduced with the video demonstration. To that end, parents were asked to score the less liked, liked or most liked features of

the PChCT. The scale uses five points from which “less liked” corresponds to 1, “liked” corresponds to 3 and “most liked” corresponds to 5.

PChCT resource	Mean	Var	SD
Space interface	3.10	0.7263	0.8522
Events interface	3.0	0.7368	0.8583
Text messages	2.55	1.2078	1.0990
Room-view/spatial location	3.35	0.5552	0.7451
Sound	3.4	0.9894	0.9947
Room-picture	3.7	0.7473	0.8645
On-demand	3.4	1.4105	1.1876
Digital-album	3.2	1.6421	1.2814
Activity-aware	3.3	0.8526	0.9233

Table 6-5 Overall responses to interfaces, services and PChCT deliveries

From table 6-5, we can see that most of the PChCT’s resources are scored around the average (“liked”), and we believe that this average perception might be related either with lack of engagement with the video demonstration or with the absence of a hands-on experience of the tool.

Next we explore attitudes when parents’ scores are grouped by children’s age. At this level we are contrasting only feelings to G2 and G36. G1, which explores individual attitudes, is reserved until section 6.3. Figure 6.2 presents responses to G2 grouped by children’s age. We observe that all age-groups have an average of “agree”. That is, across all the age-groups ubicomp tools might be welcomed.

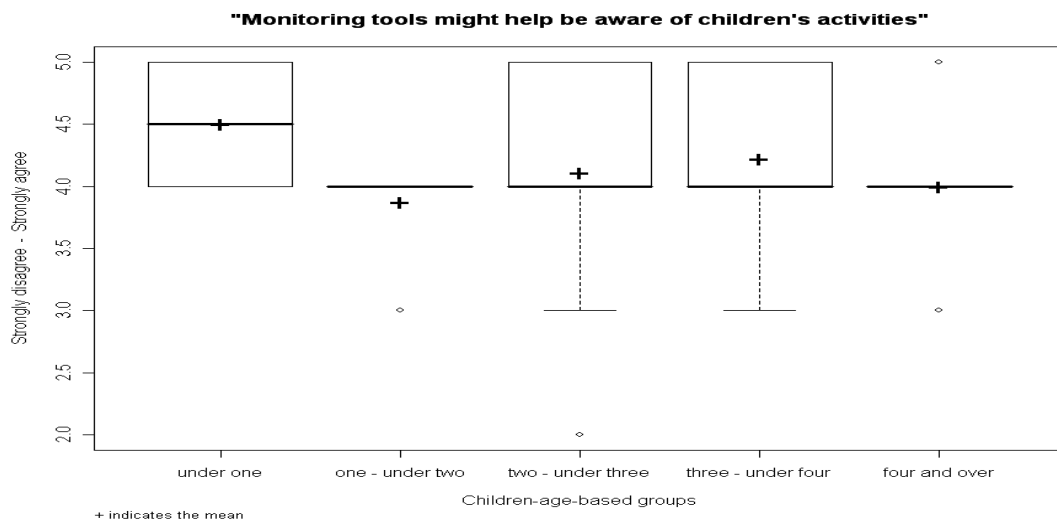


Figure 6.2 Responses to “considering help from monitoring tools” by child’s age group

However, considering G36 (figure 6.3), we see grater uncertainty.



Figure 6.3 Responses to “PChCT usefulness” by child’s age group

Table 6-6 shows that the under-one and four-and-over groups are the ones with higher proportions of BDA’s and we could argue that these groups seem to disagree with the usefulness of at least some of PChCT’s resources. Could these groups’ positions be related to social issues? For instance, could parents from the under-one group feel that their parental role is being threatened?

Group	Mean	Var	SD	N	BDA	UN	BAG	NA
under-one	3.78	0.9153	0.9567	28	11%	14%	75%	0
One-to-two	3.41	0.3987	0.6314	41	7%	44%	49%	1
Two-to-three	3.7	0.8139	0.9022	84	9%	27%	63%	0
Three-to-four	3.74	0.3402	0.5832	84	2%	26%	72%	0
Four and over	3.39	0.9140	0.9560	28	22%	18%	61%	0

Table 6-6 Responses variability to “PChCT usefulness” by child’s age group

We must bear in mind that there are only two parents within these groups, a factor which is likely to influence the variability of attitudes. Also, that group G36 is built from categories that measure different aspects of the PChCT, and that some measures are related to particular uses of the tool which were seen only through the PChCT video demonstration, a factor that might also be influencing the perception of the PChCT’s usefulness.

We conclude therefore that the overall attitude seems positive to the acceptance of technology-based tools to complement childcare related tasks. However, when particular tools are suggested, in this case the PChCT, parents’ perceptions are more reserved. One possible explanation to this might be associated with the absence of a direct experience with the tool. In order to explore further explanations of parents’ attitudes, the next sections examine each of six groups of responses, G1 to G6.

6.3 Individual analysis of categories (G1-G6)

As in section 6.2, we begin by observing the distributions of overall scores in each category to note positive responses; then we explore the score distributions and use basic statistics to identify apparently troublesome questions, i.e. questions with low scores, within each category.

6.3.1 *Aware of children's activities (G1)*

The G1 category is used to elicit parents' experiences of caring for children in the home. It aims to identify parents' awareness of their children's activities. It is known that domestic activities might be influenced by family culture, social status and other factors such as cultural parenting.

Before moving on to explore parents' responses it is important to note the childcare scenarios underlying the questions within this category, as this might help to understand parents' responses. To encourage parents to be aware of children's activities this category includes some of the following scenarios:

- Children like to explore. Despite the differences in children's ages we expect that parents are aware at some level that children learn mostly through exploration, and that this child's activity might lead to a fall or other more serious accidents.
- The parent usually knows the cause of the child's pain. We expect parents to recall circumstances or situations in which the child has had a bad experience, either through of illness or due to an accident; have parents struggled to identify why the child was crying?
- Children are not with their parents all of the time. Sometimes parents need to attend to some household tasks and perhaps leave children in a different home space.

We expect that if parents are aware that children sometimes undertake risky activity or if parents are aware of missing any significant experience of the child (either achievement or accident) because they are not always with the child, then they might perceive technology as a useful tool to help capture those moments.

Returning to the survey analysis, the first exploration considers overall scores to G1 (figure 6.4). It can be seen that 25% of the responses were reserved: “undecided” or “disagree”. We could therefore conclude that parents are aware of children’s activities and so they might be receptive to technology assisting with some levels of parenting awareness.

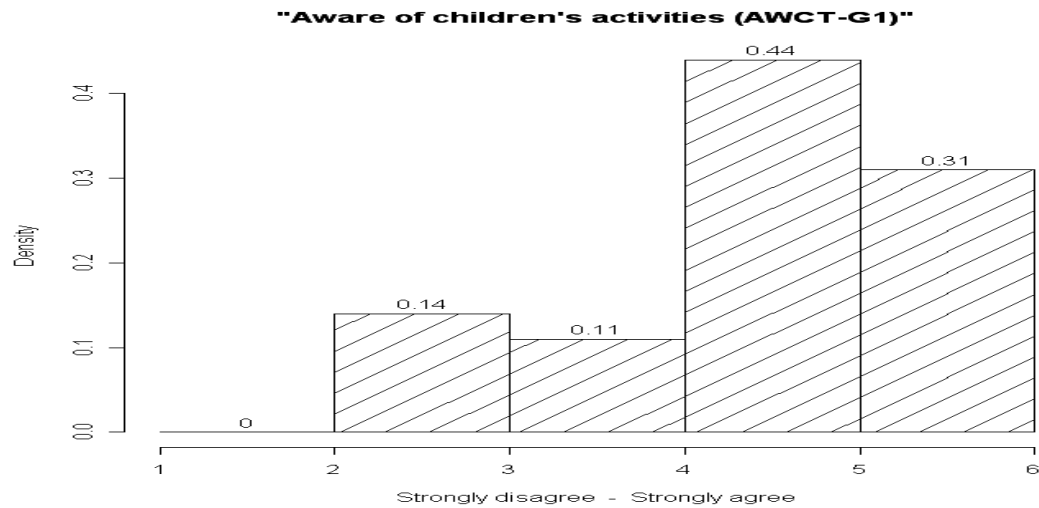


Figure 6.4 Score densities to the “aware of children’s activities” category

To explore what might underlie the “undecided” and “disagree” responses we analyse responses to each question within this category (table 6-7). We could observe that questions G, “*When my child visits the GP I usually know what the source of the child’s pain is*”, and M, “*When I am cooking my child is often in a different room*”, are the troublesome questions, i.e. the questions with the lowest scores, and also that questions M and A, “*Very active children are the ones that often undertake risky activities*” have the highest variance, 1.16 and 0.91 respectively.

ID	Question/measure	Mean	Var	SD	SDA	DA	UN	AG	SAG
A	Active-children/risky activity	3.8	0.9052	0.9514	0%	15%	10%	55%	20%
B	Parent’s awareness to active children	4.25	0.5131	0.7163	0%	5%	0%	60%	35%
D	Children like to explore	4.7	0.3263	0.5712	0%	0%	5%	20%	75%
G	Parents know any child’s happening	3.55	0.8921	0.9445	0%	15%	30%	40%	15%
M	Parent-cooking/Child in different room	3.3	1.1648	1.0809	0%	35%	10%	45%	10%

Table 6-7 Variability of responses for the “aware of children activities” category

Why does this group include a degree of variability? Is there something related to the scope used for questions? Are the situations of individual parents different from what is explored within this category? We now explore, therefore, what might have influenced parents’ attitudes to questions A, G and M.

Question A asks if only very active children undertake risky activities. For instance, those children who like to climb and jump everywhere, who like to explore inside electric sockets or who are curious about the cooker knobs. Thus, “undecided” and “disagree” scores could possibly indicate that parents consider that any child might eventually be exposed to risky activity. Have those parents had any bad experiences with their children? A less ambiguous question might have been whether all children sometimes undertake risky activity.

Question G considers the scenario in which the child is ill or has had an accident, and in the context of visiting the doctor invites parents to answer a question typically asked by a GP: “How did it happen?” We assumed that within this context parents could consider how technology might help them to record, for example, a child’s accident. However, the fact that 45% of the responses were a reserved position (“Undecided” or “Disagree”), makes us wonder whether this is an issue of question wording. It might be also that the scenario used for this question conflicts with the parents’ experiences, e.g. parents with very young children may never have visited a GP with their child. Both are important issues and are further explored in section 6.4.1.

Question M considers scenarios in which parents are situated, for example, cooking and looking after their children. The assumption here was that when parents are cooking, children are typically left watching the TV or playing in a different room. However, it appears that there are other criteria parents might use to decide where and when children have to be placed in a different room. One possibility is that parents do not consider the kitchen to be a risky room for young children if the parent is present, or that some safety measures can be put in place in order to make the kitchen safe. It might be that parents prefer to keep children close to them. If so, is the child’s age a factor influencing the attitude of parents?

In considering responses to G1 in terms of the child’s age groups (figure 6.5) we can see that those parents with the youngest children are the ones with more variable responses to the G1 questions. Parents with children under two years have the most uncertain attitudes; they have the highest variance. So, is there something in common between these two parents groups’ attitudes?

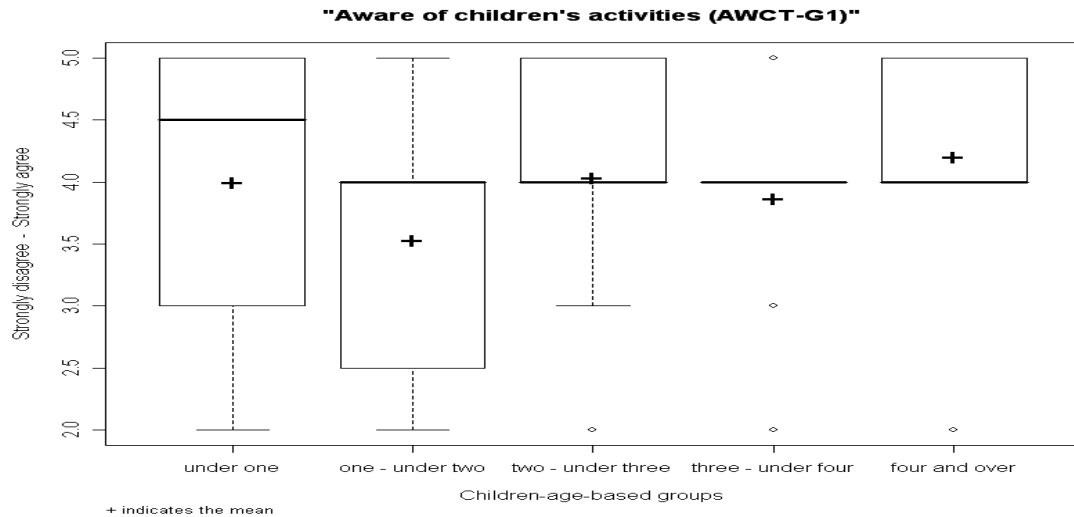


Figure 6.5 Responses to “aware of children’s activities” by child’s age group

Although we are not in a position to make broad generalizations, in considering the response distributions for each group we would argue that the younger the child the greater the uncertainty about some aspects of parental awareness. As we suggested above, it seems that if the child is still a baby with no walking or talking skills, then a parent might be uncertain about what level of awareness might be needed in her own situation.

We could summarize this section by arguing that parents were asked to think about how aware they need to be when caring for their children in the home. The degree of awareness might be associated with the age and development of the child, their physical and psychological skills, and the particular care given by each parent. Two of the responses from parents to the open question that relates to the social contexts explored for G1, are given below:

- *“Your house should be safe enough for children to explore or you should keep them closer.”*
- *“Some children do not leave parents alone to do anything.”*

There surely exists other social scenarios which might influence parental attitudes, but which lie outside the scope of this exploration. Section 6.4 investigates possible links between “troublesome” questions and individual attitudes.

The next section explores whether or not parents consider that technology-based tools could help with childcare tasks.

6.3.2 The use of a tool for monitoring (G2)

Our interest in this category is to understand how parents might perceive the use of a computational tool to help them to supervise children's activities. For instance, if parents believe that they need to be vigilant and they realize that there are moments in which the child is alone, then we might expect from them to be sympathetic to the use of monitoring tools to complement their attendance to childcare.

To explore to what extent parents might consider the use of a monitoring tool to support them with the task of supervising their children's whereabouts, we use scenarios such as the following:

- Monitoring tool: we assumed that child supervision is usually done concurrently with other tasks and that parents might perceive that a monitoring tool could help them.
- Recording children's development or isolated events: are young children exposed to incidents or accidents associated with their early years of psychological and physical development? We expect that parents might consider that if the child is alone then the tool could help to capture some of the child's experiences – for example, when they start to try to walk.

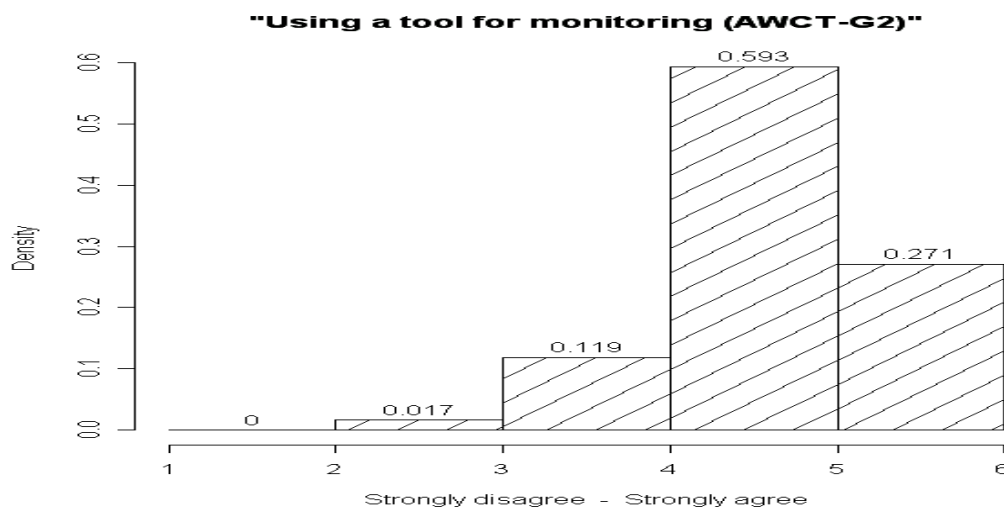


Figure 6.6 Score densities for the “considering a tool for monitoring” category

Figure 6.6 presents the level of agreement or disagreement associated with all the responses to the G2 group. We can see that around 14% of G2 scores are reserved. We also observe that “strongly agree” scores for G2 (approx. 27%) are less than those for G1 (31%): at least some parents moved from “strongly agree” to “agree”

positions. We could conclude, therefore, that most parents might welcome the use of technology to support some of the activities involved with childcare.

What might be the circumstances that encouraged parents to consider the help of a tool for monitoring purposes? First, here are the questions that comprise group two:

- Monitoring tools can help parents to supervise children's activities (question C)
- Having a record of the child's development is a good idea (question H)
- I wish to monitor the child's activities if the child is in a different room (question O)

You might realize that these are similar to questions in G1, but now framed in terms of the use of technology.

Table 6-8 shows that question C, "*Monitoring tools can help parents to supervise children's activities*" has the least positive attitudes. We wonder whether the word "supervise" might convey too strong a meaning, and if true, it might add to the uncertainty of the parents' responses: surveillance is something typically perceived as a threat to privacy [Moncrieff et al, '07]. Additional support for this argument is the observation that other monitoring-related questions such as recording child's experiences with a tool were scored more highly.

ID	Question/measure	Mean	Var	SD	SDA	DA	UN	AG	SAG
C	A tool for children supervision	3.78	0.5087	0.7132	0%	5%	21%	63%	11%
H	Recording children experiences with a tool	4.5	0.2631	0.5129	0%	0%	0%	50%	50%
O	Use of a tool if children in different room	4.0	0.3657	0.6048	0%	0%	15%	65%	20%

Table 6-8 Responses variability for the "using a tool for monitoring" category

We observe, however, that overall parents seem to consider a monitoring tool to be useful. Moreover, although it is the question with the lowest responses, question C still had 74% of agreement so we might argue that the level of social acceptance for monitoring tools appears to be associated with the benefits parents might receive in using the tool.

For instance, the question O, "*I wish to monitor the child's activities if the child is in a different room*" and the question M, "*When I'm cooking my child is often in a different room*" seem to be related in terms of identifying the need and its potential support.

In considering the scenario behind each question within this group, therefore, we would argue that parents could make use of a tool, for example, to keep a record of the child's experiences, and that they might use the tool for monitoring purposes if the child is not with the parent; however, they may think twice in the context of surveillance.

We can also ask: what might be the relation, if any, of these responses with the child's age groups?

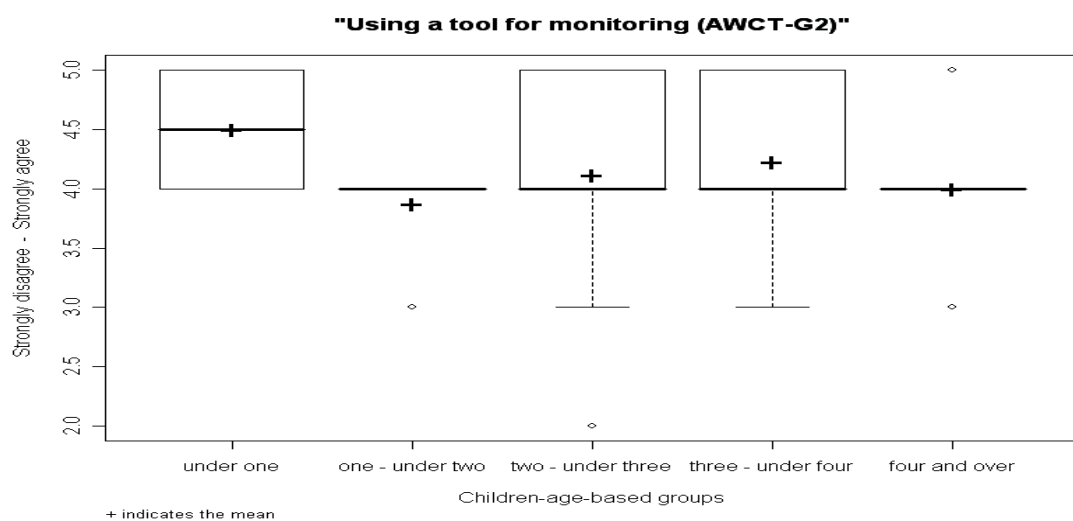


Figure 6.7 Responses to “considering a tool for monitoring” by child’s age group

Figure 6.7 shows that in general there are uncertain (“Undecided”) positions from parents with children aged one year and over, but, because of its “disagree” responses the group “two-to-three” is in particular the most uncertain.

Why might this group in particular be aware of considering monitoring tools? It is difficult to find an explanation for these variations across children's groups, and the number of responses is rather small, so we will reserve the exploration of individual attitudes to this group's questions to section 6.4. However, to offer a preliminary indication of the diversity of social scenarios that might underlie responses to G2, we present the responses of two parents to the open question of our survey questionnaire:

- *“I think they are roughly useful for anyone with small children.”*
- *“I think my child is old enough to play by her own.”*

These responses suggest that the child’s development is a factor that might influence the perception of the usefulness of a monitoring tool.

6.3.3 PChCT as the monitoring tool (G3)

Within this section, the goal is to gain a sense of parents’ views about using the PChCT tool to help them with the monitoring or supervision of children’s activities. Questions in this category are to some extent associated with the tool’s features as reviewed during the video presentation, and with the questions from G1 and G2 in relating to some of the awareness scenarios associated with caring for children within the home.

It must be stated that from this point on we intend to explore parents’ feelings about the usefulness of some of the PChCT’s resources for monitoring; however, we are conscious that parents have not had any direct physical experience with the tool, and their responses may depend more on general attitudes. In spite of this, we expect that if a broadly positive response exists to the “Using a tool for monitoring” group of questions, and that if parents are conscious of the need to be aware of their children’s whereabouts, then a similar response should be given to the “Use of the PChCT as the monitoring tool”.

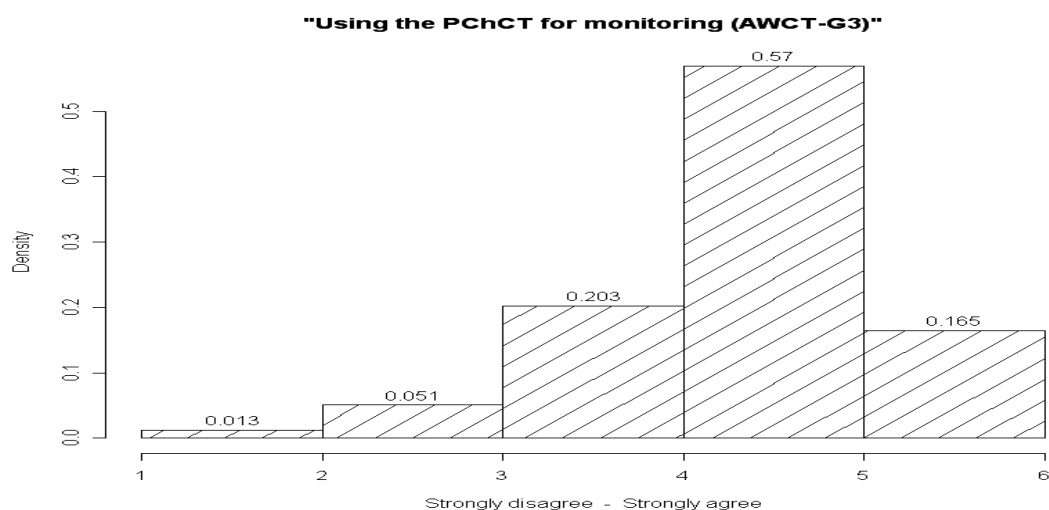


Figure 6.8 Score densities for the “using the PChCT for monitoring” category

Figure 6.8, which groups all responses given to questions within this category, shows that there is an overall positive attitude when considering the use of the PChCT: 74% of the scores indicate “broad agreement” with the use of this tool. However, if

compared with responses to G2 (figure 6.8) we can see a shift away from “strongly agree”, and a shift towards “undecided” responses. Also, we observe that there are “strongly disagree” responses in this group.

From table 6-9, we observe that the troublesome questions are questions I, “*I wish the tool could record the first experiences of my child e.g. crawling or walking*”, and question E, “*The tool helps parents with supervising young children*”; most of the “undecided” and “disagree” scores are for these questions.

ID	Question/measure	Mean	Var	SD	SDA	DA	UN	AG	SAG
E	PChCT helps with the children’s supervision	3.68	0.7836	0.8852	0%	11%	26%	47%	16%
F	PChCT helps identifying risky activity	4.1	0.3052	0.5525	0%	0%	10%	70%	20%
I	PChCT usage to record children’s experiences	3.65	1.2921	1.1367	5%	10%	25%	35%	25%
R	PChCT represents what happen in the room	3.85	0.2394	0.4836	0%	0%	20%	75%	5%

Table 6-9 Responses variability for the “using the PChCT for monitoring” category

We also note that questions E and I have a similar meaning to questions C and H (from G2); the only difference is that G3 questions are applied in the context of the PChCT tool.

The interesting element here is that E and I questions are scored lower than their counterparts C and H; BAG scores for C and H were 74% and 100% whereas for E and I are 63% and 60% respectively. This might again be an indicator that direct suggestions for using a particular tool to support parenting activities might raise social concerns. Or it may simply reflect greater uncertainty about the details of PChCT in particular.

Let us then explore the perceptions to the use of the PChCT tool from the perspective of children’s age groups. From figure 6.9 we observe that, with the exception of the group three-to-four, the age groups return at least some low scores; and that the “under-one” group is the one with “strongly disagree” responses. In addition, bearing in mind the sample size of this group also, we found that a quarter of the responses of the group “four and over” were “disagree”. So what might be the relation, if any, between these parents and low-scored questions?

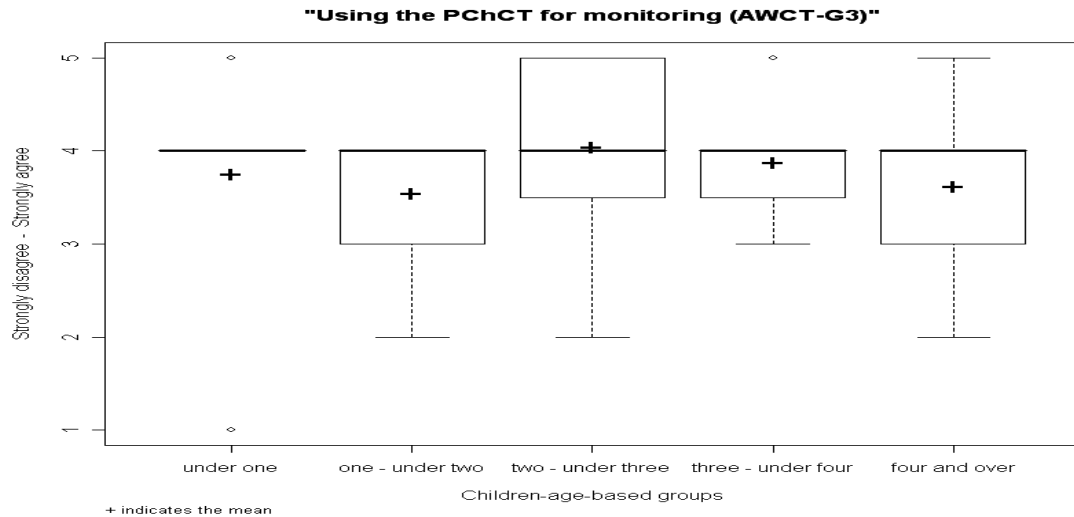


Figure 6.9 Responses to “using the tool for monitoring” by child’s age

Could it be the case that the question I, “*I wish the tool could record the first experiences of my child e.g. crawling or walking*” is out of context for parents with children aged four-and-over? Does this not apply to them anymore? Or are parents with children under one year old feeling that they might be excluded from experiencing how their children grow up? Is the child’s development, therefore, a factor influencing parents’ feelings about ubicomp tools such as the PChCT? We return to these issues in section 6.4:

The next section explores the degree of acceptance to some of the PChCT’s features that might support the supervision of children’s activities.

6.3.4 PChCT collaboration/interaction (G4, G5)

This section examines the responses of parents to some of the collaborative and interactive mechanisms offered by the PChCT tool. However, because the only information about the PChCT resources is from the video demonstration, we are being careful to avoid questioning parents about the concepts beneath the collaborative and interactive resources. For instance, to select, use and feel the possible benefits of the activity-aware service, it might be essential to have technical information such as awareness areas and distances, information that only lasts for about one minute in the video presentation, and we are not sure that parents were able to grasp it. We restrict ourselves, therefore, to asking about the usefulness and overall availability of these tool features.

PChCT's collaboration (G4)

To explore the acceptance of the PChCT's collaborative features we included questions about the *space* and *events* interfaces, and whether these might help parents to trust the tool.

Figure 6.10 shows the distribution of responses given to this category. We can observe that there are very few “Strongly agree” responses, and that overall less than 50% of the responses are positive.

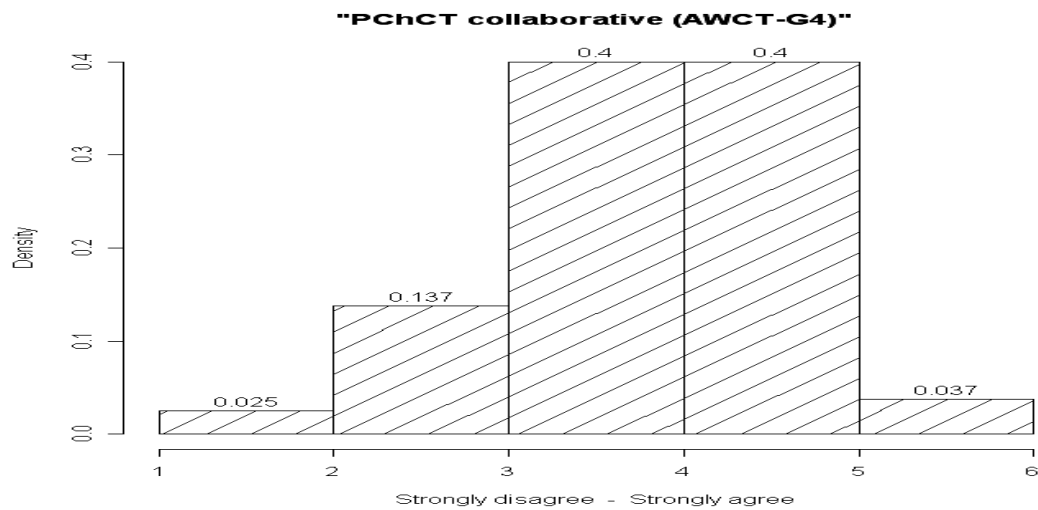


Figure 6.10 Score densities for the “PChCT collaboration” category

It seems that parents were not certain whether the PChCT's features might help with parental tasks. Is it an effect of the lack of hands-on experience? Are people often hesitant about giving an opinion about something that is not familiar to them? Did the video demonstration fail to engage people with the PChCT's resources?

Table 6-10 shows basic statistics to explore overall attitudes and “troublesome” questions within this category. We observe that question T, “*Continuous monitoring is something I would use most of the time*”, despite of having some “Strongly agree” responses, seems to contribute significantly to the lower scores, and to a lesser extent question Q, “*All of the available collaborative characteristics can make me trust the tool*”. However, in general we can see a high proportion of “Undecided” responses across all the questions.

Considering question K first, “*Collaborative services (text, space-view, sound and images) meet all of my needs for the monitoring of the child*”, we would argue that

parents might find it difficult to decide whether a monitoring tool is useful if they have not tested it, or possibly are uncertain whether the tool meet all of their needs for childcare support.

From a different perspective, we might argue that the words “monitoring” and “supervising” may have been perceived in particular ways; e.g. 24 hour surveillance. If so, then we might explain the negative responses to questions K and T. Of course, if parents cannot identify the PChCT’s usefulness then we cannot expect them to trust the tool (question Q).

ID	Question/measure	Mean	Var	SD	SDA	DA	UN	AG	SAG
J	Collaborative features help to look after children	3.5	0.4736	0.6882	0%	10%	30%	60%	0%
K	Collaborative services meet what is needed to supervise children	3.2	0.6947	0.8335	0%	20%	45%	30%	5%
Q	Because of the collaborative features I can trust PChCT	3.25	0.6184	0.7863	5%	5%	50%	40%	0%
T	I would use PChCT for continuous monitoring	3.2	1.1157	1.0563	5%	20%	35%	30%	10%

Table 6-10 Responses variability for the “PChCT collaboration” category

One way to paraphrase the apparent response to the PChCT might be:

Although as a parent I have no experience with the PChCT, it seems that there are some features that might help with the monitoring of children’s activity, however I am not sure whether these meet my needs, and in any case it is not really “surveillance”.

When reviewing responses according to the children’s age groups (figure 6.11), we can observe that parents with children in the “two-to-three” and “four and over” groups returned the most negative responses, but the one-to-two group was the most uncertain overall; 66% of the responses in this group were “undecided”. The group four-and-over appears to be the least engaged by the PChCT’s features: 50% of the responses broadly disagree with the usefulness of the tool’s resources.

Although we note that the sample size for the group four-and-over is very small, we might ask again whether or not attitudes to the PChCT features might be associated with the stage of the child development; we return to this question in section 6.4. We close the analysis of this group by presenting responses of two parents to the open question of the questionnaire:

- “Seems useful but not all the time...”
- “Undecided about use... feels a bit big-brotherish.”

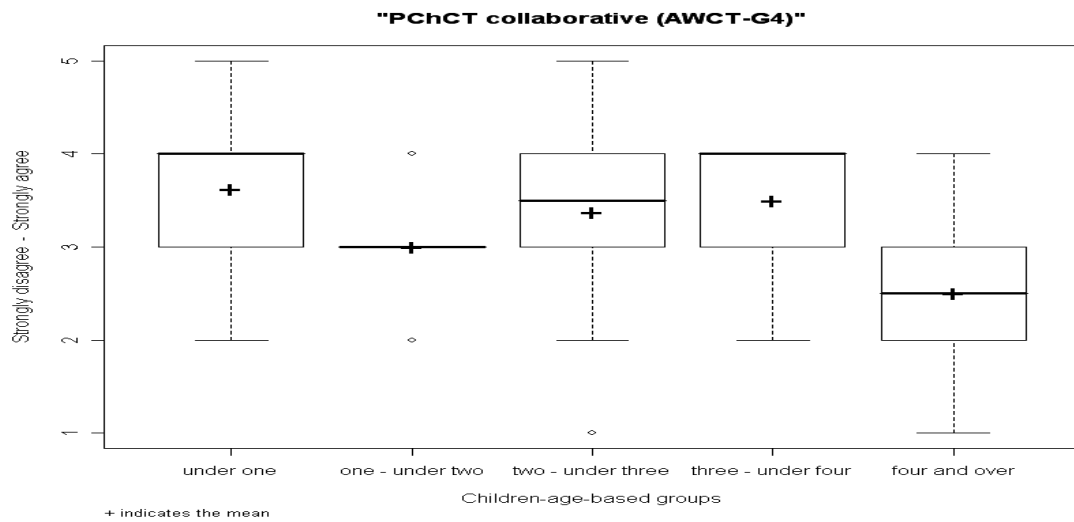


Figure 6.11 Responses to “PChCT collaborative” by child’s age group

PChCT’s interaction (G5)

Within this group of questions we explore some of the PChCT’s features that take into account the user’s participation. These include facilities that the user can configure to determine the level of collaboration given by the system. For instance, the “awareness artefacts” section allows the user to select which augmented artefacts of which the user wishes to be aware. As in the previous section we bear in mind that parents’ experience with the PChCT is limited. We therefore limit our analysis to two questions that refer to the availability of the resources within the user profile interface that allow the user to adapt the system’s collaboration and to request the room’s picture.

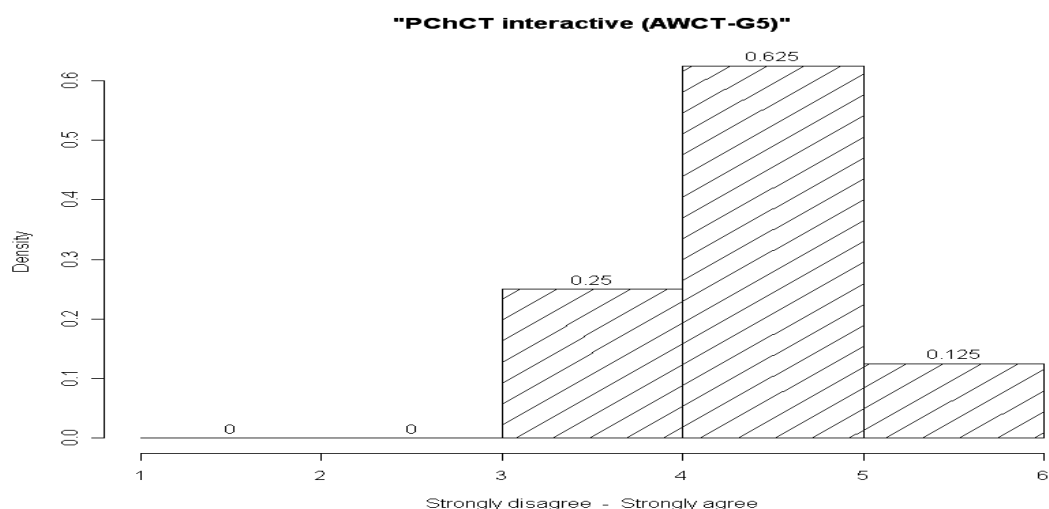


Figure 6.12 Score densities for the “PChCT interactive” category

Figure 6.12 shows the distribution of responses for group G5. We observe that there is “broad agreement” in this category, with 25% of the scores “Undecided”.

Table 6-11 shows that question V, *“The request for the room’s picture is easy to understand”*, is more highly scored than question U, *“I like it that the system allows me to change the configuration of the awareness levels”*. These two questions explore how easy (and desirable) parents might find the use of these two interactive resources. We observe that the perceptions of parents for both facilities are very similar.

ID	Question/measure	Mean	Var	SD	SDA	DA	UN	AG	SAG
U	Interactive mechanism to control aware activity reporting	3.80	0.3789	0.6155	0%	0%	30%	60%	10%
V	Easy interaction to upload the room’s picture	3.95	0.3657	0.6048	0%	0%	20%	65%	15%

Table 6-11 Responses variability for the “PChCT interactive” category

Again, for the uncertain scores, we could argue that these may be associated with the absence of a hands-on experience. Responses grouped according to children’s age groups in figure 6.13, show that the group four-and-over completely agrees with the usability of these PChCT resources whereas the opinions of other groups are divided. One possibility might be that if children are fully developed and aware of dangers around them then parents might be especially interested in controlling the system’s collaboration. However, why do the other groups express some doubts about these PChCT’s features?

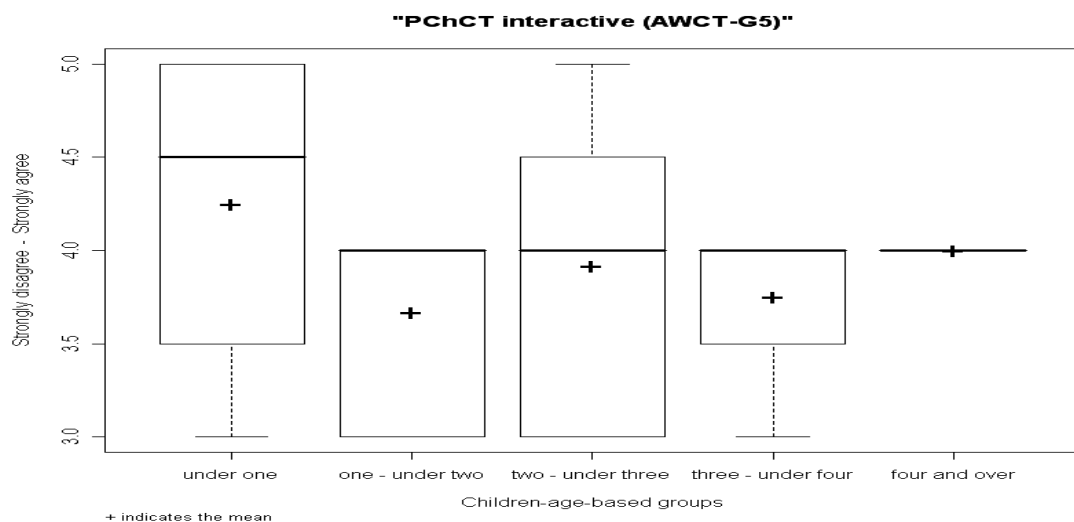


Figure 6.13 Responses to “PChCT interactive” by child’s age group

The group sizes and the number of questions within this category are two factors constraining our observations, but it is possible that the child’s age and development

might also influence responses to this category; discussion of which is reserved for section 6.4.

6.3.5 PChCT “activity-aware” collaboration (G6)

This section explores the parents’ understanding and acceptance of the use of the “aware-activity” service. As previously stated, this service is provided for children who might need constant supervision, e.g. very active children. In addition this service is divided into three sub-services, awareness areas which parents can use to select three different levels of collaboration: awareness of general activity, awareness of alert activity or awareness of warning activity. G6 also covers the embedded services: sound and media. We are interested in identifying whether the aims of these facilities and services are understood.

We again group the responses to all questions to present their density distribution (figure 6.14). The first thing we note is the decrease in “Strongly agree” responses, a trend since the questions in G2. This suggests that the more weight we put on suggesting the PChCT in particular as a tool that can help parents, the more cautious parents are in their responses to such a tool. Nevertheless, overall parents perceive usable resources from this level of collaboration.

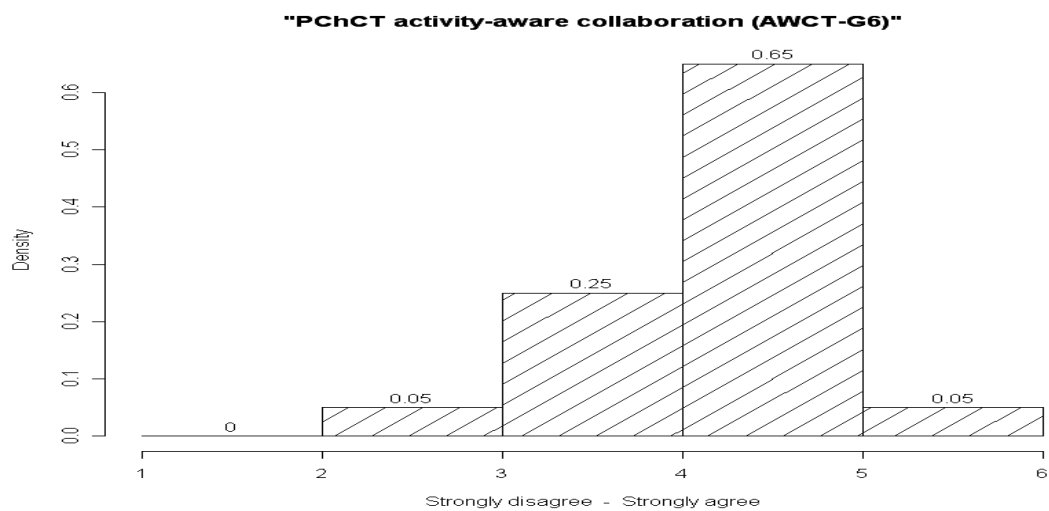


Figure 6.14 Score densities for the “activity-aware collaboration” category

In considering responses to individual questions (table 6-12), we find that question L, *“The identification of the aware levels (general-activity, alert and warning) is clear when using sound collaboration”*, and question N, *“Aware levels (general-activity,*

alert and warning) are easy to understand when using the space interface”, are those with least positive attitudes.

Regarding question L, there might be different factors influencing parental attitude. One possibility is that the sounds (in the video presentation) were not loud enough and that parents struggled to associate them with the awareness levels. It might also be the case that the differences between sounds used to report each of the awareness levels is indistinguishable.

From the basic statistics for these questions we could argue from the responses that the concepts underlying awareness levels were perhaps not understood at all by some parents from the video demonstration.

ID	Question/measure	Mean	Var	SD	SDA	DA	UN	AG	SAG
L	Aware levels are identifiable with its associated sound	3.55	0.3657	0.6048	0%	5%	35%	60%	0%
N	Aware levels are understood within the space interface	3.45	0.4710	0.6863	0%	10%	35%	55%	0%
P	Room's picture helps clarifying levels of aware proximity	3.80	0.3789	0.6155	0%	5%	15%	75%	5%
S	Aware levels to identify risky activity	4.00	0.3157	0.5619	0%	0%	15%	70%	15%

Table 6-12 Variability of responses for the “activity-aware collaboration” category

To identify the three awareness levels within the space interface, the parent has to be aware of the three different colours, green, yellow and red, which are used to indicate general, alert and warning activity respectively.

Another factor supporting the argument for the lack of engagement with the video demonstration is that all the parents on average scored as “liked” most of the collaborative resources of the PChCT (see table 6.5), which seems to be in accordance with the parents’ perceptions to this group of questions. This might be an indication that parents could have not obtained enough information to offer more detailed responses.

Considering how these parents’ responses vary with children’s age groups we find no particular trends or anomalies.

Finally, to complement our observations of parental attitudes to the PChCT's activity-aware collaboration, we include two related responses to the open question of the survey questionnaire:

- *“I would definitely welcome an alert for dangerous areas (i.e. fire), but this would not replace general healthier safety awareness or vigilance that parents should be undertaking anyway.”*
- *“I would use one as it would allow me to identify dangers and where exactly my child was in the room.”*

To summarize, we could argue that parents have a positive view of the PChCT's usefulness. However, we have also observed that the attitudes of parents might be associated firstly, with their cultural ways and ideals of attending to these childcare activities and secondly, to the child's development. We have identified that some parents appear to be uncertain whether collaboration offered by ubicomp tools such as the PChCT could potentially provide what they might need for enhancing childcare-related tasks. In that regard two elements may have influenced parental perceptions: the amount of information available from the video demonstration, and the absence of hands-on experience with the tool. Nevertheless, there are other social scenarios that might also increase the uncertainty of parents when considering the acceptance of ubicomp tools, e.g. when both parents work, the use of private childcare, and house size.

The next section discusses in more detail the observations from this section from the perspective of individual attitudes. The objective is to look for stronger associations between social attitudes and the PChCT tool.

6.4 Discussion of results

So far we have explored parental perceptions of the PChCT in terms of overall scores for the six different categories of questions used to measure its possible social acceptance. We have also considered variations in parents' responses according to their children's age. However, bearing in mind that our sample population limits us in generalizing results, we decided to explore potential social contexts that might help to understand individual attitudes and responses.

The aim of this section is to identify the social factors that might influence the less positive individual responses. To that end, we explore the “troublesome” responses made by individuals with generally more negative responses in order to explore whether the attitudes of parents might be affected by technical and/or social factors.

Group	Question	BDA (%)
G1	(M) “When I am cooking my child is often in a different room”	35
	(G) “When my child visits the GP I usually know what the source of the child’s pain is”	15
	(A) “Very active children are the ones that often undertake risky activities”	15
G2,G3	(C) “Monitoring tools can help parents to supervise children’s activities”	5
	(E) “The PChCT tool helps parents with supervising young children”	11
	(I) “I wish the PChCT tool could record the first experiences of my child e.g. crawling or walking”	15
G4	(J) “Collaboration offered by the tool can support me looking after the child”	10
	(Q) “All of the available collaborative characteristics can make me trust the tool”	10
	(K) “Collaborative services (text, space-view, sound and images) meet all of my needs for the monitoring of the child”	20
	(T) “Continuous monitoring is something I would use most of the time”	25
G6	(N) “Aware levels (general-activity, alert and warning) are easy to understand when using the space interface”	10
	(L) “The identification of the aware levels (general-activity, alert and warning) is clear when using sound collaboration”	5
	(P) “Availability of the room’s picture helps to clarify the three distinct levels (general-activity, alert and warning) of the aware proximity”	5

Table 6-13 Survey questions with “broadly disagree” responses

Table 6-13 shows the questions that were scored with BDA, broadly disagreement scores. We believe that this level of discussion will complement previous observations and at the same time help us to identify and understand social factors around the use of ubicomp technology to support parent’s everyday activities.

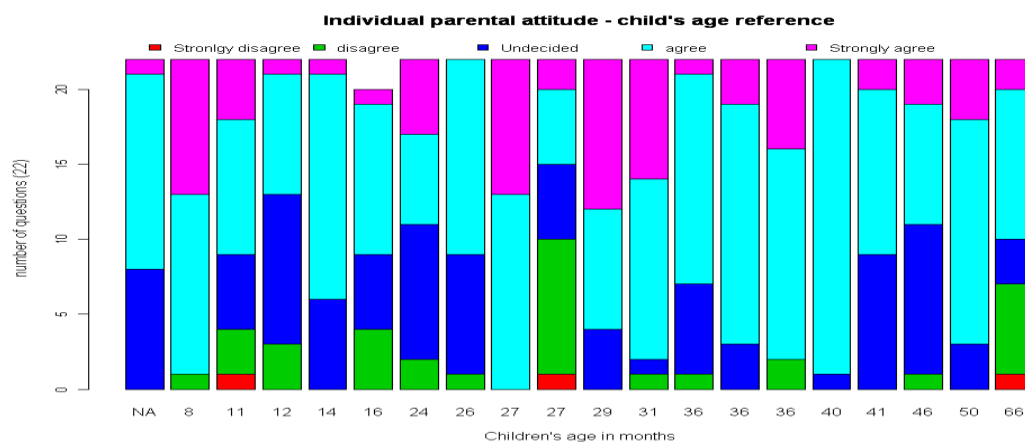


Figure 6.15 Individual parent’s responses to the “main” section of the panel survey

To begin our discussion we present figure 6.16 in which each of the vertical bars represent the individual parents responses to the 22 questions included in the “main” section of the survey questionnaire; each parent is represented by her child’s age (in months), with the youngest at the left and the oldest on the right. At the extreme left we have included the responses for the parent who did not record the child’s age.

This data starts to give insight into whether children’s stage of development and parenting philosophy affect parents’ attitudes. For instance, if we compare the responses from the two parents with children aged 27 months, we might ask why their responses are quite different.

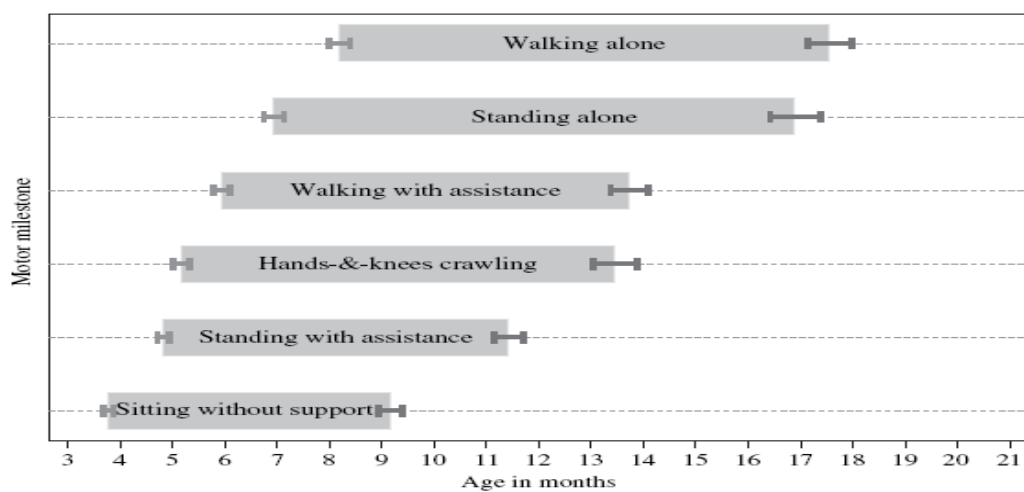


Figure 6.16 Windows of milestone achievement expressed in months [ibid]

Because we have argued that the child’s age and stage of development seem to be a factor influencing parental attitudes to ubicomp tools such as the PChCT, we present in figure 6.17 the milestones of motor development for children age 3 to 21 months [WHO, ‘06].

The next sections explore individual differences and “troublesome” questions in each of the sections of the questionnaire in turn.

6.4.1 Awareness of children activities (G1)

First, we must remember that this group of questions focuses on placing parents in scenarios before assessing the PChCT’s usefulness, and does not evaluate quality of parenting, for example. Our interest is in understanding whether or not the scenarios used were unclear and thereby contributed to uncertain attitudes. However, as noted

previously, other factors affecting responses in this group might also include child's stage of development and parenting philosophy.

Table 6-14 presents parents who gave low responses to the questions within this group. For example, the column for the group "one-to-two" indicates that parents with children aged 12 and 16 months gave a score of 2 ("Disagree") to questions A and B and M and G respectively.

	under one		one-to-two		Two-to-three				Three-to-four	four and over
Child (months)	8	11	12	16	24	26	27 ^{R10}	31	36 ^{R15}	66
Q's	G	M	A,B	G,M	M	G	A,M	M	A,M	M
Score	2	2	2,2	2,2	2	2	2,2	2	2,2	2

Table 6-14 Individual responses with BDA scores to awareness of parenting

* Rn represents the parent's column in figure 6.22

We observe that 7 out of 20 parents "disagree" with question M and 3 out 20 with question G and question A, so we explore these negative responses from two perspectives: the scenario used for questions and potential social issues.

Cooking and childcare

Why would some parents say that their children are often with them when undertaking cooking tasks (question M)? One possibility might be that the activity of cooking includes selecting food to be cooked; the choice of casserole or saucepan; letting cooked food cool; and tidying up the kitchen. For which of these activities would the child have to go to a different room? In addition, the activity of cooking and serving the meal may overlap. For example, while finishing cooking the parent prepares the table and serves the family's meal. This may include their children's presence, or it may be the case that the kitchen is also the dining room.

Secondly, the everyday activities of child and parents, may also be affecting parental perceptions. For instance, the parent might attend to all of the household work including the cooking, while the child is not at the home; therefore question M might be irrelevant. We could also imagine a scenario in which both parents work and the child is full-time in a nursery setting, then we could understand the value of sharing any available time between parents and children even in the kitchen and during cooking.

The potential impact of private childcare on parents' responses is additionally supported if we consider the setting in which the study was carried on out: 75% of children are in full-time childcare (8:00 am to 5:00 pm); so the likelihood is high that some of the parents in our sample had children in full-time private childcare.

Awareness of children's experiences

Parents' knowledge of the child's experiences can be explored in different contexts. Firstly, one might consider again the use of private childcare. For instance, if children are in full-time private childcare then it is possible that parents know about the child's incidents/accidents through the caregiver's reports, and not because the parent had directly observed the child's accident. The parent may therefore not be fully aware of the child's pain because the child was not under his or her supervision.

Secondly, we might consider the kind of incidents or accidents occurring within a childcare setting or within the home [Royal Society for the Prevention of Accidents, '02], [Macgregor, '03] some of which are treated locally without visiting a GP. For example, scalds or bumps might be treated in the home. So how often does a child visit a GP? Nevertheless, how could a parent know about an accident that her child has experienced if the parent was not in the same room? Children under two years might not be fully able to communicate what has happened to their parents [Sharman, et al, '04].

Children's risky activities

Overall we would argue that the responses of parents indicate that not only do children with high levels of activity undertake risky activity, and also that parents were aware of the effort that can be needed to supervise young children's activities.

In summary, we have presented some social scenarios and factors that might affect parental responses to the survey category concerning awareness of children's activities. The following sections explore individual perceptions of using monitoring tools and in particular the PChCT to support their childcare-related activities.

6.4.2 Tools for monitoring children's activities

In this section we discuss categories G2 and G3 together because there seem to be common factors influencing parents' responses. We recall that the difference between these two groups of questions is that G2 asks about perceptions of monitoring tools in general whereas G3 refers in particular to the consideration of the PChCT as the monitoring tool. As we have argued in section 6.3.3, when we suggest more specific ways that parents can use the PChCT tool, responses seem to become more reserved. In table 6-15 we list those individuals who "disagree" with some of the questions included in this group.

	under one	one-under two	two-under three	four and over
Child's age	11	16	27 ^{R10}	66
Q's	I	C,E,I	C,E	E,I
Score	1	NA,NA,2	2,2	2,2

Table 6-15 Individual responses with BDA scores to the monitoring tools

We can see that the parent of the sixteen-month-child did not score questions C and E. We start our exploration with these "troublesome" questions, which refer to "supervising" children's activities.

Supervising children's activities

We have already argued that the use of the word "supervising" might affect parents' responses. We think that some parents envisaged the "surveillance" of their child's activities from different perspectives, including the treatment of individual privacy. For example, if we contrast the "broadly agree" responses given to questions C (74%) and E (63%), which ask about perceptions of "supervision", with scores given to questions O (85%), "*I wish to monitor the child's activities if the child is in a different room*" and F (90%), "*The tool can help me identify when the child is close to potentially hazardous artefacts*", then we observe that the context of "surveillance" or "supervising", children's activities is uncertain for at least some parents.

Can we therefore make a stronger assumption that the use of the word "surveillance" frightened parents? We assert that this was the case. Considering in particular the parent whose child is 5.06 years old, we argue that because at this age children are expected to be fully skilled and relatively independent for "any" activity, then it

might be the case that the parent is reluctant to consider the use of a monitoring tool for supervising the child's activities.

Recording of children's experiences

To what extent might parents consider uses of the PChCT other than for monitoring? We assumed that if parents and children were not in the same room then parents could be interested in recording some of the child's experiences such as attempts to walk or crawl, and other less happy moments such as accidents; however, it seems that for some parents this may not be the case. One factor that could influence responses of parents with children under two years old is their view of parenting. We would argue that both parents (11 and 16) might feel that at this stage children need help and human supervision to support them with their milestone achievements, as seen in figure 6.17, something that technology could not replace. If the parent is with the child most of the time how could she miss her child's precious moments? In addition, we should not discount private childcare, which adds value to the briefer moments that parents can share with children. To complement our observations we present responses from two parents to the open question of the questionnaire:

- *"May consider, although prefer to keep a closer eye on the child personally."*
- *"I would not be happy having my child for more than very short period in a different room & would try to ensure this room was child friendly."*

In summary, we have considered parental responses to the suggestion that ubicomp tools, and in particular the PChCT tool, might support them in attending to the childcare task. From our explorations we argued that social contexts should be borne in mind if we want maximize parents' acceptance of this type of ubicomp tool. For example, we explored that social issues such as privacy and culture might affect the adoption of technology within the home.

The next section investigates parents' attitudes to the collaborative and interactive features offered by the PChCT.

6.4.3 PChCT collaboration

This section explores scenarios that might have affected parents' perceptions of usefulness of the resources offered by the PChCT to collaborate with the monitoring

of children’s activities. As noted previously, we are aware that to some extent parental responses depends on information given in the 7 minute PChCT video demonstration and also that the child’s stage of development might be affecting the responses of parents.

Table 6-16 lists parents who “disagree” with at least one of the survey questions (categories G5 and G6) which asked parents about their opinions of the PChCT collaborative resources for childcare.

	under one	one-under two		two-under three		three-under four		four and over
Child	11	12	16	24	27 ^{R10}	36 ^{R13}	46	66
Q’s	N,K	T	T	T	J,L,N,K,P,Q	K	T	J,K,Q,T
Score	2,2	2	2	2	2,2,2,2,2,1	2	2	2,2,2,1

Table 6-16 Individual responses with BDA scores to the PChCT’s collaborative resources

Firstly, we can observe that parents in all child-age groups disagree with at least one question in this category, secondly, that questions T and K have the most disagreement across all child-age groups, and thirdly, that parent 27^{R10} and parent 66 are highly participating with “broadly disagree” scores.

We start by exploring technical and social contexts that might have influenced parents’ responses to questions T and K and then we will try to identify and understand attitudes of the parent with the high rate of disagreement (27^{R10}).

First, we could ask whether the information in the video demonstration was not grasped by parents. That is, if parents did not realize that continuous monitoring (in question T) refers to the “aware-activity” service and confused it with a 24-hour surveillance service then we could have expected some uncertainty in parents’ responses. In this case, we would argue that the video demonstration session failed to engage some parents. We have also already argued that the lack of hands-on experience is possibly a factor influencing parents’ perceptions of the PChCT’s usefulness.

Second, we could ask whether this level of awareness of the PChCT might meet the needs of parents for monitoring their child’s activity (question K). Table 6-17 compares responses to questions C, E and T (column CET-Q), which deal with the use of the PChCT to supervise children’s activities, and parents’ responses to G36,

which measures overall perception of the PChCT. This table might support our hypothesis that these parents are quite reserved about using a ubicomp tool on a continuous basis, but positive about other PChCT features. For instance, we can consider the case of parent 16 (parent with the 16-months-old child) who despite being negative about the use of the “activity-aware” service might be counted among the PChCT’s supporters: 46% of this parent’s scores went to an “Agree” position. If we assume that this child is in her early crawling/walking stage then it is possible that the parent wants to follow the child’s development and we could argue the parent might feel her role is irreplaceable.

	CET-Q			Overall attitude of these parents to the PChCT (G36)									
Parent	C	E	T	Mean	Var	SD	N	SDA	DA	UN	AG	SAG	NAs
12	3	3	2	3.21	0.3351	0.5789	14	0%	7%	64%	29%	0%	0
16	N	N	2	3.3	0.5641	0.7510	13	0%	15%	39%	46%	0%	1
24	3	4	2	3.35	0.5549	0.7449	14	0%	7%	57%	29%	7%	0
46	3	3	2	3.2	0.3351	0.5789	14	0%	7%	64%	29%	0%	0
66	4	2	1	2.92	1.1483	1.0716	14	7%	36%	14%	43%	0%	0

Table 6-17 Positions to supervision-related questions and PChCT in general

Similarly, if considering that the child aged 66 months is independent, self-confident, and so on, then her parent might reject the idea of using the “activity-aware” service due to privacy issues.

Finally, we explore what might be affecting the parent 27^{R10} attitudes to the PChCT. The first element is that this parent has scored “disagree” with each of the group questions, and in particular, this parent scored the PChCT with 2.64. We believe that this parent was never engaged with the PChCT. For example, it is only this parent who disagreed with the availability of the room picture, a resource that is very positively perceived in general. In table 6-18 we compare the attitude of parent 27^{R10} with the attitudes of other parents to the PChCT’s usefulness. We could argue that parent 27^{R10} generally disagrees with the perceptions of the rest of the group.

	Overall attitude to the PChCT (G36)								
	Mean	Var	SD	N	SDA	DA	UN	AG	SAG
Parent 27	2.64	0.8626	0.9287	14	7%	43%	29%	21%	0%
Group 2-to-3	3.91	0.5432	0.7370	70	0%	1.5%	27%	50%	21.5%

Table 6-18 Parent 27 individual attitude to the PChCT

We would state in fact that this parent appears to dislike the idea of ubicomp tools within the context of parental tasks. Below is the parent response to the open question of the questionnaire:

- *“Not for me - I found it hard to leave my daughter with an adult other than myself. So, I'd find it hard to put trust on a computer system - however if I had a large family I would consider it.”*

In summary, we explored whether parents might be engaged by the resources the PChCT has available for monitoring children's activities, and to what extent parents accept the approach suggested by the PChCT for collaboration. Our findings reflected some parental uncertainty as to whether the tool would provide the support needed when caring for a child in the home. In particular they seemed cautious of using the tool on a continuous basis. We explored two kinds of possible complications which might be associated with parents' reservations. The first social complication includes children's development and parenting philosophy, and the second involves technical issues associated with understanding the PChCT usage or the absence of a hands-on session.

6.4.6 Using and trusting ubicomp tools

We use this additional space to discuss some comments about the PChCT given by parents in the open question section of the survey questionnaire: Could you tell us your views about using these types of tools to monitor children's activities? Would you use one yourself? Why?

From the responses of parents we identify two further issues which might constrain the acceptance of the PChCT: time constraints and trust of this type of ubicomp tool.

With regard to time constraints we observe that time is very valuable to parents, and if the usefulness and usability of ubicomp tools is not clear then their acceptance may be limited:

- *“I would be too busy looking at the tool to do any housework.”*
- *“by the time I would have pressed button I could go & check on my child.”*
- *“It is interesting to be able to monitor my child but feel I would end up constantly watching the monitor.”*

With regard to trusting ubicomp tools, parents might be positive only if tools such as the PChCT have been fully proved by others:

- *“I'd find it hard to put trust on a computer system.”*
- *“I would probably use this but would need to know more about it + see it in operation.”*

In summary, we have discussed negative responses in particular and offered some scenarios that might account in part for some of the parents' feelings. We found that parents who were negative about the activity-aware collaboration had a similar attitude to all of the PChCT's features. We hypothesized that the 11-month-old child might be experiencing his or her first attempts of crawling or walking and the parent might feel therefore that the tool cannot substitute her/his role. In addition, we found that absence of direct experience might be another factor influencing responses. For instance, despite the parent of the 27-months-old child (2.3 years) feeling positive about scenarios in which the tool might be applicable, she/he seemed to struggle in understanding the use of some of the collaborative and interactive resources offered by the PChCT.

We conclude that, in spite of the social and technical reservations affecting parents' responses, they consider the tool has some worthwhile facilities which might help them to be aware of their child's whereabouts. Finally, we observed that this type of ubicomp design, as well as being reliable, should avoid overloading parents' time if it is to be considered within everyday settings.

6.5 Chapter conclusion

This chapter has explored the possible degree of acceptance of the PChCT from the “Can technology support parents?” panel survey. The investigation of parental attitudes was conducted at three different levels. The first level explored overall attitudes to the PChCT's usefulness. The second level examined the degree of acceptance of particular PChCT's resources/features, and the third level explored whether social factors might influence individual responses. We found that parents' uncertainty increased when we suggested particular ways to use the PChCT in parenting tasks. Variations in responses appear to be linked to both technical and social factors. Technical-related constraints might include a lack of engagement with and understanding of the information given in the video demonstration. It was assumed that with the information given during the PChCT video presentation

parents would understand the identification of children's risky activity when using the tool awareness levels. This seemed to be a false assumption, as suggested by the low scores given to the PChCT's resources offered to support some of the parental tasks. Additionally, the absence of hands-on experience may have affected parents' responses. Regarding social issues, it seems that some parents may fear that the technology might undermine their caring role. Some responses seem to suggest that there are many different situations affecting childcare activities, such as the child's stage of development, household attendance, parents' job, and the use of private childcare, that make it difficult to decide whether ubicomp tools can provide what parents need.

Finally, we could argue that in general the PChCT tool was positively received and that even though parents were not given the opportunity to use the tool physically they appeared to understand most of the approaches that the PChCT offers for collaboration. However, we should not overlook the uncertainties about whether technology could fully support parental activities.

The next chapter gives results from the PChCT usability study in which parents were able to use the tool. The responses of parents from the usability study together with the results presented in this chapter are used to explore the social acceptability of ubicomp tools that might support parents in the home.

CHAPTER VII

USABILITY STUDY RESULTS

As explained in chapter five, the usability study explores the acceptability of ubicomp tools, such as the PChCT, that aim to support some of the everyday activities of parents. The usability study combined two activities, the activity-monitoring session and the usability experience session. The activity monitoring session used the context-aware room prototype to collect two hours of data each from the activities of three parents and their children. This information was processed and used to drive and personalize the PChCT usability experience session. Each of the usability sessions consisted of an introduction, a hands-on session and an interview. This chapter explores responses from the interviews with parents to ascertain the PChCT's acceptability.

Results from each PChCT usability experience help us to understand to what extent these kinds of ubicomp tools meet the needs of parents in supporting childcare-related activities. Results from the usability session are used to complement previous observations from the panel survey study.

Section 7.1 describes the approach used to explore parents' perceptions from the usability study. Section 7.2 presents parental responses about the PChCT's usefulness. Section 7.3 examines the PChCT's usability. Section 7.4 discusses the degree of parents' acceptance of the PChCT. Finally, section 7.5 concludes the chapter.

7.1 Usability experience analysis approach

The usability session helps to identify the degree of acceptance of the PChCT. To identify the degree of parents' acceptance we analyze responses from each of the interviews and explore attitudes to the PChCT regarding usefulness:

“The PChCT's usefulness is defined by the worth and relevance of its resources to support and empower parents with their parental tasks”, and usability:

“The accomplishment of monitoring tasks using the PChCT is straightforward and pleasurable, without any complexity to master its use.”

Table 7-1 presents the collaborative and interactive resources of the PChCT to be explored in terms of their usefulness – practical worth and applicability – and usability – ease use/learning and pleasantness.

Collaboration					+	Interaction								
Interfaces		Presentation mechanisms			Services				Configuring/Adapting					
Space Events		Text visual media sound			On-demand Digital-album Aware-activity			Media request		Awareness levels	Awareness distances	Awareness services	Awareness artefacts	sound <

Table 7-1 PChCT resources and features to be explored in terms of usefulness/usability

Firstly, the usefulness and usability of the PChCT's **collaboration** is explored with regard to the available resources to support parental supervision – interfaces, presentation mechanisms and services. The exploration of the practical worth (section 7.2.1) of the collaborative resources concerns parent's perceptions of the importance of having these elements within the tool whereas their applicability (section 7.2.2) explores the benefits parents identify when using the tool. These PChCT features are also explored in terms of their ease use (section 7.3.1) and how pleasurable (section 7.3.2) the system's collaboration might be perceived to be.

Secondly, the usefulness and usability of the PChCT **interactive** features is explored in terms of their support for parents' participation, to request or configure different levels of collaboration. The exploration of the practical worth (section 7.2.3) and applicability (section 7.2.4) focuses on the PChCT's resources available for configuring/adapting different levels of the system's awareness, which also define different levels of collaboration. The exploration of ease of use/learning of the PChCT's features (section 7.3.3) covers the interaction approaches offered to users to configure the system's awareness and to request the media interface (and the room's picture). The parents' perceptions of the pleasantness of the PChCT's interactive mechanisms (section 7.3.4) are explored for the configuration approaches and the tool's portability.

Finally, section 7.5 discusses parents' responses about the strength and weakness of the current development of the PChCT and the enhancements to the tool that could improve the degree of collaboration with parental activities, i.e. our last analysis explores whether this type of ubicomp tool could be not only useful and usable but also desirable [Stanley, '02].

7.2 Usefulness

The PChCT ubicomp tool offers support to parents in supervising their children, in particular informing parents of their children's whereabouts and reporting possible risky activity. The interactive mechanisms provide in addition the user profile interface which can be configured to adapt the system's collaboration to the parents' current needs.

The results presented in the next section indicate to what extent parents perceive that the collaborative features (services, presentation mechanisms and interfaces), and configurable resources (awareness artefacts, awareness distances, and so on), satisfy the two aspects of usefulness: practical worth and applicability.

7.2.1 Practical worth of the PChCT's collaboration

The PChCT's collaborative features must be perceived by parents as worthwhile and enhancing to the supervision task of looking after their children in the home. Parental attitudes to the PChCT's collaboration are explored from interface to service levels. We start with the interface level because this might represent the entry point to the PDA user-interface and perhaps the main elements with which users would interact.

7.2.1.1 Practical worth of Interfaces

The aim of this section is to identify how valuable parents find the interfaces offered for collaboration, in terms of how well these could serve without further elaboration to support parental tasks.

As part of our overall observations we would note that parents appear to have their own preferences with regard to the interfaces used by the system to report collaboration, i.e. the space and events interfaces. These preferences seem to be based on two aspects: activity representation and the ability to upload the room's picture. With regard to the context-activity representation in general it seems that

parents prefer visual resources rather than plain text, which appears to be the main reason for the positive response to the space interface.

To start our discussion about why, or in which context(s), these interfaces might be considered useful we present two questions used to explore parents' views.

- Considering only the two main interfaces, space and events, which of them do you consider more useful in terms of information it offers to support you with the monitoring of the child's activities?

Parent (3.10y) – *“the space interface gives you a dynamic panorama of what is occurring within the room; the probable useful thing from the events interface is that there you can see a list of the events history, which you could use to select a particular event and revise what was happening on that moment.”*

Parent (2.4y) – *“the space interface is more representative to the activity occurring within the room” ... “events interface is not practical at all.”*

Parent (0.6y) – *“I cannot see myself using the events interface too much, it is quite abstract” ... “the space interface is more useful” ... “it seats the game of where everything is in the real room.”*

These views of the *space* and *events* interfaces identify some of the features that parents might consider worthwhile if the PChCT is used in the monitoring of children's activities. On the one hand, the layout of the image used in the background of the space interface seems to be an important element in engendering positive attitudes to the space interface. We used the following question to explore about this perception:

- Does the room layout, used at the background of the room-view interface, help you with the spatial identification of activity?

Parent (3.10y) – *“you can immediately see the hazardous area or point.”*

Parent (2.4y) – *“Yes, I think I can identify activity from the room's layout.”*

Parent (0.6y) – “*especially if you know the room... don’t know whether it may be easy to label to where they are... but I suppose it’s your lounge, you would know anyway.*”

For parent 0.6y’s experience we used the room layout that belonged to the parent who participated in the activity-monitoring session and, therefore we find some hesitation about whether the parent’s room layout is or is not in the background of the space interface. Despite this, parent 0.6y seems to agree that the room layout in the background might be considered part of the useful features of the space interface.

On the other hand, the events interface seems not to be informative enough, or it is difficult to associate with what is actually occurring within the room in which the child is active.

We additionally asked parents to assess numerically these interfaces (table 7-2):

- Using a 1 to 5 scale, being 5 the highest, what is your score for each of these interfaces?

Parent	Child’s age	Space interface	Events interface
ML	0.6 year	4	2
RB	2.4 year	5	3
YM	3.10 year	5	3

Table 7-2 Parents’ assessment of the space and event interfaces

At first glance we observe that table 7-2 shows how the three parents assign different levels of usefulness to the *space* and *events* interfaces.

An additional observation of interest from both the hands-on session and the interview is the association between the interfaces’ perceived value and the access to the picture of the room. For instance, in our direct observations we see that, once parents received a report from the system, their first impulse was normally to upload the room’s picture followed by, for example, whispering “right, there you are”. From the interviews, parents appear to consider the availability of the room’s picture to be an important and worthwhile element of the interfaces.

Parent (3.10y) – “*when using the interfaces I need to touch twice the display or to select the event from the list and this will give you the room’s picture.*”

Parent (2.4y) – *“the offering to retrieve the room’s image within any interface is I think the best of all.”*

Parent (0.6y) – *“I like the way you can click on it and you can actually see... the visual, natural image of the room.”*

From the above responses we observe that there seems to be an overall acceptance of the *space* interface and a less positive attitude to the *events* interface. This initial exploration suggests issues in the quality of the presentation mechanisms used to communicate activity. The next section therefore explores parents’ perceptions of presentation mechanisms used within these interfaces to inform them about the child’s activities.

7.2.1.2 Practical worth of presentation mechanisms

The usefulness exploration of the resources of this tool aims to determine how useful parents find the mechanisms used to convey activity. These mechanisms include visual-activity, text-based messages, the room’s picture and sound.

In the previous section we pointed out that parents considered the visual representation of activity to be useful, but that there are also other mechanisms used to inform them of their child’s activities. We now explore parents’ preferences of delivery mechanisms used to report activity. We asked, for example:

- Which of the monitoring resources do you consider of help? (space-interface objects, events-interface messages, media, sound)

Preferences appear to be related to the effort needed to understand and draw a clear picture from what is being presented within the PChCT interfaces, of what might be occurring within the room. In this respect the simplest presentation mechanism – and the most worthwhile – is the room’s picture. This media object seems to engage parents because it apparently allows them to check or prove the system’s reliability. That is, they value the existence of the room’s picture to determine whether what is being reported by the tool is true or not.

Parent (3.10y) – *“counting with the media allows users verifying what is being reported by the tool.”*

Parent (2.4y) – *“the room’s picture is useful to verify what is reported.”*

Parent (1.6y) – *“But the media interface I think...” “because you can actually see your child there...”*

With regard to interfaces, and in particular the space interface, the coloured spots used within the space interface to represent activity visually appear to be useful to parents. It seems that this resource fulfils its purpose of communicating two kinds of information: location and proximity.

Parent (3.4y) – *“the use of coloured spots helps to the identification of the room’s activity.”*

Parent (1.6y) – *“here (the space interface) you are seeing the location of the child’s activity...”*

Parent (0.6y) – *“...when you look at the space you actually got an idea yourself of where they are.”*

In addition to these mechanisms, parents’ appear to identify the sound as a useful resource that might help them identify the child’s activity without, for example, looking at the user-interface.

Parent (3.10y) - *“sound is useful...”*

Parent (2.4y) – *“you can make a relation between the sound and the message.”*

Parent (0.6y) - *“the sound is something good to have...”*

The least preferred of the presentation mechanisms was the text-based messages. Although the extent to which the PChCT is found to be useful, usable and desirable is considered further in section 7.4, we present here some of the general comments on this interface.

Parent (3.10y) – *“I think I am not informed enough about the room’s activity with the events interface.”*

Parent (2.4y) – *“because it does not tell you too much.”*

Parent (0.6y) – *“probably the text could be more useful if it add something more explicit about distances.”*

The following section, explores parental perceptions of the collaborative services.

7.2.1.3 Practical worth of services

With regard to services it appears that each parent may prefer to select and configure services according to current circumstances. That is, parents appear to want to navigate through the available services based on the level of awareness demanded by their children's activity, which may depend on the child's level of development. We explored perceptions about awareness services in terms of their applicability to reduce the tool's intrusiveness:

- Considering your experience with the available services, which might fit your needs best in terms of reducing interruptions of your activity?

Parent (3.10y) – *“activity-aware service together with aware levels is of real use to me.”*

This parent seems to identify some utility in using the tool on a continuous basis and presumably understands how awareness levels can be used to control the rate of information delivery.

Parent (2.4y) – *“what I can see more useful is when the child is getting close to a hazard point and to be informed”... “in my case the availability of the digital album is very important...”*

This parent throughout the interview indicated that her child is very active, which contributed to her positive attitude to the activity-aware and digital-album services.

Parent (0.6y) – *“services allow you to control interruptions from the tool”... “on demand is useful if you don't want use the reporter all of the time.”*

This parent identified that with the use of the awareness services she could control the degree of collaboration. In particular, the parent seems to be interested in the on-demand service.

From these attitudes we might observe that parents may want to adapt collaboration levels according to individual needs, which might in turn be associated with the child's development. In the particular case of parent 0.6y, she argued that her child is always under adult supervision, which might possibly explain her interest in the on-demand service. Has her child started crawling or walking?

Parent 2.4y perceives that with the activity-aware and digital-album services she could avoid missing any of her children's experiences:

"In my case with my daughter, for example, how she made herself the scratch on her face, how a lump appeared on her head? Where it comes from? Then for this situation you go and look there (referring to the digital's album) and I'm sure you will find an answer there..."

The children's development may therefore be a factor influencing parents' attitudes to the PChCT. Does parenting philosophy also affect their perceptions? We discuss some of these issues in section 7.4. Next we explore to what extent parents might identify some benefits of using the PChCT for supervising children.

7.2.2 Applicability of the PChCT's collaboration

We observed in the previous section which resources of the PChCT parents believed might be valuable in the context of monitoring children. In this section we present the benefits parents feel might be obtained from the tool in terms of attending to household tasks and looking after children at the same time. Under what circumstances or contexts would the tool's resources be of use?

7.2.2.1 Applicability of interfaces

What might be the contexts in which the interfaces could help with childcare tasks? We are looking for situations or circumstances that might encourage parents to use the PChCT interfaces. The questions used to elicit information about these parental attitudes were, for example:

- Do you consider that this tool might collaborate with you when doing the household and caring the child at the same time? For instance, when you are making the beds and your child is, say, playing within the living room.

- Consider a situation in which you are doing any of the housework such as cooking or cleaning, do you think there might be a chance (time/space) of looking on the room's image?

We explore then what type of scenario parents present to identify possible benefits of using the PChCT's collaborative resources.

Parent (3.10y) – *“if you are upstairs you can use the tool to see the child's activity” ... “You do not need to shout, what are you doing?” ... “I do not need to stop my doings.”*

Parent (2.4y) – *“the tool might offer some comfort if I am doing something and I use the interfaces to know about the child's doings.”*

It seems that parents agree that using the PChCT might help keep an eye on children's whereabouts and thereby accomplish household work with less interruption. However, the *events* interface seems to be something that parents would not often use.

Parent (3.10y) - *“the last interface I think I might use of if doing the household work is the events interface.”*

Parent (2.4y) - *“the events interface is something I could say has limited application.”*

Parent (0.6y) – *“reading the list of events imply time” ... “maybe the only benefit using the history of events is that you can pick up one of your interest.”*

The time factor is significant in the last parent's (0.6y) response. It is possible that parents are viewing the use of the events interface as an extra time demand on top of the usual daily workload which might be felt to be unacceptable. This is explored further in section 7.4.

7.2.2.2 Applicability of presentation mechanisms

Under what circumstances do the various presentation mechanisms help with childcare tasks? We seek to understand the associations parents make between some scenarios of daily care of children with the tool's presentation mechanisms. As with the interfaces, we use some scenario-based questions to explore the applicability of the tool's mechanisms, for example:

- Did you find any advantage having embedded sound within the space and events interfaces?
- Does the information, either with messages or visual elements, represent what is occurring within the room?

We already pointed out that parents seem to welcome the availability of the room's picture. We explore here particular contexts in which parents might perceive the benefits of this and other presentation mechanisms, such as sound.

Parent (2.4y) - *"the room's image is actually a reporter of activity"... "I imagine myself cooking then I heard an alarm, and there you thought, I would like to see what she is doing, then you ask for the room's image and you might comfort yourself when you realized that everything is OK."*

We could explore this parent's example from different perspectives. For instance, we could think about the parent identifying that if she wants to be sure everything is fine with her child then she would upload the room's picture. From another perspective, the parent may be considering uploading the room's picture as the easiest and quickest way to identify the child's activity while attending to other household tasks.

Parent (0.6y) - *"you actually look at the distance with the picture... so it would never make you go and see them..."*

This parent appears to support the previous parent: a quick glance at the room's picture could avoid interrupting other household activities.

A quite different context of use from the above parent is the observation that the room's picture might help to trust other less preferred aspects of the PChCT such as the *events* interface, which reports activity using text messages.

Parent (2.4y) - *"the use of the text messages is limited unless using the media uploading to verify that information" ... "I could not need to interrupt my doings if I can use the tool to see what my child is crying."*

With respect to sound, parents give a very positive response to its presence. Parents realized that the embedded sound is useful to reduce, for example, the demands of monitoring the reports being delivered within the interfaces. That is, hearing the awareness sound they can identify the associated event and avoid looking at the interfaces too often.

Parent (3.10y) - *"hearing the sound might be enough to identify the awareness of the activity" ... "yes...you can use the sound to identify the type of the activity."*

Parent (2.4y) - *"yes...I imagine myself cooking then you heard an alarm, and there you thought, I would like to see what she is doing then you ask for the room's image..." ... "you can make a relation between the sound and the message."*

Parent (0.6y) - *"does it change? It changes when it is closer... yes... that's was good... because it can make you hear I think... you know... to whether the child is close..." ... "yes... I think yes... 'cause it is like an emergency sound, doesn't it?"*

With regard to the presentation mechanisms in the *space* and *events* interfaces, as discussed previously, visual alerts in the *space* interface are more highly regarded than the text messages in the *events* interface.

Parent (3.10y) - *"...here you can immediately see the hazardous area or point" ... "...because the coloured spot means the child is there..."* If considering the text interface, *"I would use the artefact ID, given with the message, to identify if there is any aware activity" ... "For instance, if the child is close to the fireplace it is a warning activity."*

Although there might be further issues (see section 7.4) in the way this parent interpreted information delivered to the *events* interface, we could observe that this parent compares presentations between the *space* and *events* interfaces to express her preference for the visual representation of the child's activities.

Parent (2.4y) – *“information delivered by the tool definitely helps with the monitoring of the child”... “It is there where you can observe how the point is moving...”*

Parent (0.6y) – *“because here (the space interface) you would see the colours...”... “But here, if the spot turns red you may know if they're in danger...”*

These two parents also support the mechanisms used within the space interface to represent activity. As stated by parent 1.6y, the apparent movement of spots might be to some extent identified as the child's movements, and for parent 0.6y coloured spots help to identify risky activity.

In the next section we explore the benefits expressed by parents when using the awareness services.

7.2.2.3 Applicability of services

In section 7.2.1.3 we presented some scenarios that parents used to evaluate the usefulness of the tool services. We argued that each parent may consider the rate of the children's activities before supporting any of the tool's services. This section investigates to what extent parents might consider other benefits of the PChCT's services. For instance, we sought to establish if services might help to reduce intrusiveness, by asking:

- Think about doing some housework again, which of the services considered (on-demand, digital-album, activity-aware) might interrupt you most?

From their responses below, we might observe that if incidents or accidents are considered, then the perspectives of parents on the use of, for example, the digital-album changes.

Parent (3.10y) – *“I'm not sure if the on-demand service is something I could use”...*

“I won’t probably have time to replay the digital-album in a later stage”... “it might be a relief if with the use of the digital-album one could realize why the child is crying, bleeding, etc.”

This parent seems to say that the tool from the available mechanisms offered to configure the system’s collaboration – the on-demand and digital album – might not initially be of interest to her. However, the digital-album service might be considered if it could be used to provide information about the source of a child’s bad experience.

Parent (2.4y) – *“I could replay the digital-album to see not only accidents but also misplaced artefacts children were playing with”... “to find an answer why the video player started malfunctioning...”... “so you don’t need to rely on questioning your children to find out what happened”... “On-demand could be used to reduce the rate of interruptions.”*

Similarly, this parent indicates that she might make use of the on-demand service, but might also be arguing that she cannot follow children’s activities all of the time and so the digital-album is important to her.

Parent (0.6y) – *“digital-album seems to be good when somebody is looking after your child”... “you can use it to be sure they have been ok during the day”... “at least you know where, when, or what they have done”... “is like having different levels of participation, from all to none.”*

Again, the digital-album seems to be considered in situations in which parents are not directly supervising children; with regard to controlling intrusiveness this parent appears to identify that different configurations lead to different collaboration levels.

In summary, we have explored the views of parents on the usefulness of the PChCT collaboration. We established that parents were engaged by the visual elements used to represent children’s activities. Parents also considered their interaction with the user profile interface to control the level of the tool’s collaboration to be useful. Moreover, the sound mechanism was seen as useful as it reduced dependency by

parents on the visual interfaces. Individual parental needs appear to determine whether a service is considered useful. Nevertheless, other social factors such as the child's development might also affect parents' perceptions.

The next section explores the usefulness of the user profile interface and whether or not parents might accept its approach to interaction with the PChCT's resources.

7.2.3 Practical worth of resources for adapting awareness collaboration

An important aspect of the PChCT is its support for configuration by users to reduce possible obtrusiveness within domestic social contexts. The proposed framework approach to designing ubicomp tools, presented in chapter three, includes an interaction layer which users can use to participate in the system's life. Although interaction with the PDA user-interface includes other aspects such as requesting the room's picture and the tool's portability (see table 7-1), we now consider in particular the experiences of the users in adapting the PChCT's collaborative features; two further aspects, media request and portability, are discussed in sections 7.3.3.2 and 7.3.4.2. This section then, explores any scenarios in which parents might find the interactive approach of the PChCT to be useful.

Considering that the profile interface represents the means by which users can interact with the tool, our observations from interviews with parents identify the potential usefulness of the user profile interface, for instance, in configuring which of the room's artefacts one might wish to be aware of, or in selecting a particular awareness service – on-demand, digital-album or activity-aware – according to the context of the child's supervision. However, we observed that the practical use of some elements of the user profile interface, such as the awareness distances, appears to be somewhat problematic, discussion of which is given in section 7.4. In this section we focus on positive opportunities of the user profile interface features.

We asked a direct question to request information about configuring resources within the profile interface:

- Do you consider that with the configuration of the aware resources, services, levels, and so on, you could control the tool's intrusiveness? For intrusive we

meant something that you maybe don't want but that is interrupting you or calling your attention...

Parent (3.10y) – *“it is good because it allows you to decide what type of events you want to be informed.”*

Parent (2.4y) – *“with its use, you can decide what means warning areas or artefacts and that helps you select what you really want from the tool.”*

These two parents appear to agree that by using the user profile interface it should be possible to control the rate of reports being delivered to inform them about their child's activities. In particular, parent 2.4y refers to the use of awareness distances and awareness artefacts as for this purpose.

Parent (0.6y) – *“definitely it helps you restrict the rate of collaboration”... “you could get mad with the continuous sound.”*

Similarly, this parent appears to understand how the user profile interface could be configured to reduce collaboration, but additionally, she points out that the ability to turn off sound is also useful.

We would say, therefore, that in general parents consider the user profile interface to be a useful resource for participating in defining the system's collaboration, but the question remains: how might the various elements of the profile interface find applicability in the everyday activities of the parents?

7.2.4 Applicability of resources for adapting awareness collaboration

The profile interface should allow the system collaboration to be adapted as parents wish. We have already argued that one of the aims of the tool is to allow parents to participate in the system in order to define the level of collaboration to fit their current needs, e.g. reducing system interruptions. In addition, it was observed in the previous section that parents seemed to identify how useful configuration elements such as labelling awareness artefacts or turning on/off sound might be. This section

explores which kind of scenarios parents suggest when considering the applicability of the user profile interface features such as the awareness levels or distances.

To identify how parents could visualize possible benefits of configuring the awareness mechanisms, according to the context of monitoring the child's activities, we asked, for example:

- What might be the benefit of using the sensitive and threshold parameters?
- Do you consider that the aware level matters when monitoring the child's activities?

Parent (3.10y) – *“I could see that the threshold indirectly serves to define the aware areas and the rate of deliveries” ... “I could see the use of the sensitive parameter to, for example, avoid being reported if the child is in movement (bending, stretching, and so) at the same place.”*

From this parent we can note that she appears to be aware of the possibility of receiving irrelevant information. The parent identifies sensor's sensitivity as being configured to avoid reporting, for example, when the child stands in the same position and moves just their hands.

Parent (2.4y) – *“aware distances can be used to avoid the tools bothering you too much...” ... “you can decide if you want free reporting or if you want to be reported just when the child is close or around a particular distance.”*

Previously this parent identified the usefulness of interactive resources to define awareness areas and here the parent appears to say it could help to modify or adapt the degree to which she wants to be notified when monitoring the child's activities, as the parent below also feels.

Parent (0.6y) – *“I don't know how much I really need general-activity...”*, *“the thing is good here is that you can switch off general activity and you can just have it as alerts” ... “I don't know how much I need GA.”*

In general we note that parents appear to identify advantages of configuring some of the resources within the user profile interface to configure collaboration levels.

Additionally, we explore the extent to which parents consider controlling the sound to be applicable.

Parent (3.10y) – *“it could be better if you have sound only when the alarm’s activity exists... I’m thinking of something similar as the car’s alarm... so only when the alarm level is present the sound is heard...”*

Parent (0.6y) – *“I would want sound only under specific aware levels” ... “if you are somehow tired or something you can tap the option on or off as you like”*

From the feelings of these parents we observe a similar preference to control the sound according with their particular needs. However, as pointed out by parent 2.4y, it is possible to find noisy environments in which people might struggle to make use of the sound resource.

Parent (2.4y) – *“... if it is a bit louder then that’s right... “If this is an alert and... then decide to run to verify what was happening”*

We could see there are responses from some parents which indicate that they consider the user profile interface to be an important resource to tailor the collaborative approaches provided by the PChCT tool.

In summary, parents found at least some of the resources offered by the PChCT tool to help them with the monitoring of their child’s activities to be useful. With regard to collaboration, for instance, the overall benefit seems to be that parents can carry on with their household and the childcare tasks at the same time, i.e. they might not need to stop their activity to supervise the child’s activities. With regard to presentation mechanisms, for example, parents considered the “media interface” to be very useful because they consider this to be a fast resource that can be used not only to view the child’s whereabouts, but also to verify the tool’s reliability. In terms of interaction and adapting collaboration, parents in general give a positive assessment of the user profile interface’s existence, which allows them to configure the system’s collaboration.

The next section examines the extent to which parents consider the PChCT's collaboration and interaction approachable.

7.3 Usability

The accomplishment of monitoring tasks using the PChCT should be straightforward and pleasurable, with no (unnecessary) complexity. This section explores whether parents identify problems or complexity in the tool's usage, as this could affect acceptance to the PChCT. We have already argued in chapter four, that the easy-to-learn-and-use approach described during the PChCT design is intended to motivate parents to use this type of ubicomp tool. One of the ease-of-use elements present within the PChCT is the simple and self-explanatory interface design. Only a minimum of buttons exist in each interface, in recognition of the value of parents' time. Objects used to represent activity within interfaces are intended to be easy to identify as they are closely related to everyday activities. Our exploration of usability therefore includes parents' perceptions of how easy it is to use and understand the resources and features available to interact with the tool. This additionally will help us to evaluate the pleasurableness of parents' interactions with the PChCT tool.

The next section analyses the extent to which parents might perceive the features that the PChCT offers to support the childcare activities as accessible and pleasant.

7.3.1 *Ease of use/learning of the PChCT collaboration*

We have already argued that different social contexts were considered during the design of the PChCT in order to make it easy to use. For instance, the self-explanatory *space* interface uses as its background the living room layout from each of the parents' homes to facilitate the interpretation and association of activity within this interface with its real counterpart. For instance, if a spot is indicating activity around the fireplace within the space interface, this would indicate that the child is in fact near that artefact in the real room.

Considering therefore what was proposed as the PChCT's usability approach, within this section we examine the responses of parents in relation to the PChCT's accessibility.

7.3.1.1 Ease of use/learning of interfaces

We explore whether or not parents find the tool's interfaces approachable, and identify any associated problems.

Parent (3.10y) – *“the space interface elements helps with the identification of the aware activity” ... “this interface has less buttons to, for example, request the media.”*

We note that this parent seems to indicate that the coloured spots, room layout, etc, used to represent activity within the *space* interface are easy to understand. With respect to the *events* interface the parent is apparently implying that the number of steps needed to upload the room's picture within this interface (two rather than one) is time-consuming and less straightforward when compared with using the *space* interface.

Parent (2.4y) – *“the space interface is the easiest to use” ... “the events interface does not inform clearly about the room's activity; which, for example, is the most recent event?” ... “I can be cooking with one hand and with the other, for example, requesting the image to see my child” ... “I am not lazy, but within the events interface you need to find out and point to the event of interest and then request for the room's picture.”*

This parent seems to agree that it might be easy to understand activity information presented within the *space* interface and that the uses of the tool to upload the room's picture, for example, might not present a problem even if attending to other household work. With regard to the *events* interface, the parent argues that its use might be time-consuming.

From the parent's comments below we can identify a similar position to both the *events* and *space* interface: activity information presented within the *space* interface seems to be perceived as more approachable than that in the *events* interface.

Parent (0.6y) – *“I just need to have a look on it (pointing to the space interface) and get an idea of where they are, rather than sucking all of the sent messages (referring to the events interface)” ... “one of the things I like most is the space interface.”*

There is agreement among parents that information within the *events* interface is not easily associated with what is occurring within the activity-aware room. We now seek to explore to what extent the objects or elements used to represent activity are affecting parents' perceptions. The next section therefore evaluates the approachability of the presentation mechanisms used within the *space* and *events* interfaces.

7.3.1.2 Ease of use/learning of presentation mechanisms

We expected that presentation mechanisms used to inform parents of activity should be easy to use; however, we have noted that parents have raised some concerns about the approach used within the *events* interface, in particular, concerns about the activity representations within interfaces. In addition, we examine the embedded resources, with particular attention to sound.

Regarding mechanisms representing activity within the *space* and *events* interfaces we asked:

- Does the information, either within events or space interfaces, represent what is occurring within the room?
- Are the mechanisms used to represent the information easy to understand?

In other words, how easy is it to interpret the activity from the information delivered by the collaborative interfaces?

Parent (3.10y) – *“the interpretation of what is being represented within the space interface is straightforward. For example, the spots representing child closeness to an artefact”... “all of the derived information is of easy understanding.”*

This parent identifies how the representation within the *space* interface could be related to the child's activities by coloured spots which indicate proximity between child and artefact. However, it is interesting to note that this parent found all of the information within the interfaces easy to understand. To determine how this parent supports her argument we additionally asked:

- How you can identify aware-activity when using the events interface?

Parent (3.10y) – *“I could identify that with just reading what is here said... if the child is close to the heater sensor I know that that is a warning area.”*

We consider the parent’s association between the potentially hazardous artefacts and activity close to them to be valid. That is, we note that for this parent the appearance of “hazard” artefacts alone within the text report might be enough to perceive the risk level of the space in which the child is active. Moreover, it is possible that the distance between the child and the artefact is irrelevant, as this parent seems to like to use the general activity awareness service to monitor her child’s activity.

Parent (2.4y) – *“identification of the child’s whereabouts is clear with the coloured spots”... “whereas with the events interface one needs to read the text”... “you need to find the activity-event because here you are not informed”... “the message will not turn blue.”*

For this parent the resources used to represent activity within the space interface also seemed to be easy to understand. However, the parent’s argument against the *events* interface is that she could not find an easy mechanism to identify new events. As reported by the parent, it is necessary to go through the list of events to discover the recent activity. To discover how this parent might identify activity information delivered to the *events* interface we asked the same question as for parent 3.10y. The parent 2.4y argued that the uploading of the media viewer to see the room’s picture can complement information available within the events interface: *“Yes, for the messages you only need to request the image and you can immediately see where the child is.”*

Parent (0.6y) – *“the constant text ‘the child is close to’... is ambiguous... “maybe if it gave an actual word when it is close... five centimetres away...”*

Similarly, this parent argues that interpretation of the text-based reports within the events interface is not easy; suggested enhancements to this interface are discussed in section 7.4.

Regarding sound, we found that although this resource had been identified as being useful and applicable in different contexts, there were some concerns about the extent to which parents might rely on the sound to identify, for instance, awareness activity. To that end, we asked parents:

- Is the sound helping with the monitoring task?

Parent (3.10y) – *“yes... but it could be better if general, alert and warning have a different sound... so you can use the sound to identify the type of the activity.”*

For this parent the association between sounds and awareness levels was difficult. Although the other two parents identified the differences they suggested this resource should be improved.

Parent (2.4y) - *“if you are distracted, not completely aware, it is difficult to identify differences between the aware sounds” ... “I think the volume is not the solution what I could change is the sound.”*

Parent (0.6y) – *“sound is slightly distinguishable...” ... “if sound changes when the child is getting close it could be good” ... “It is easy getting accustomed to the different aware sounds.”*

In general, we found that parents struggle to identify the sound associated with each of the awareness levels. In particular, after undertaking the usability test in the parent’s home we recognized that environmental noise can affect the perception of the awareness sound. Nevertheless, the sound resource was considered valuable as a collaborative delivery mechanism. The next section helps to identify any unpleasant elements associated with the collaborative resources of the tool, for example, the awareness sound.

7.3.2 Pleasantness of the PChCT’s collaboration

In this section we present the overall pleasurableness of the PChCT from the parents’ experience with the tool. To that end, we collate into groups those responses which appear to reflect not only pleasurableness but also some level of uneasiness with, or

complexity of, the use of the PChCT's features. The first explores the mechanism used to represent activity and the second examines time consuming issues.

7.3.2.1 Reporting Activity

We have observed that parents seem to like most the visual representation of children's activities, e.g. the space interface and the media viewer (which is used to upload the room's picture). This section presents some of the parents' comments that might be used to explore the pleasurableness of the various activity representation approaches.

First, we begin by arguing that one reason for parents' positive feelings is the novelty of offering parents a picture of their children's location.

Parent (3.10y) – *“the space interface is the one I would like to use”... “I was quite excited seeing the picture of my child.”*

Parent (0.6y) – *“I didn't expect to see things, like a camera capturing how things went on”... “the media is the one I very liked.”*

Parent (2.4y) – *“That is something new for me”... “having the interface from which you can retrieve the image.”*

We can see the pleasure that the three parents felt seeing their child's picture within the PDA user-interface. However, parent 2.4y pointed out an additional scenario which illustrates a possible drawback in the room image pleasurableness:

Parent (2.4y) – *“Thinking about that if the available image reflects the aware level, I don't know”... “the image I saw she was doing nothing”... “let see... maybe not really if she is close to the toy box...”... “but you don't know if she is grabbing a toy or grabbing the scissors, for example... so I don't know really.”*

The parent seems to be aware that, in terms of representing the child's activities, even the room view might be limited if, for example, the child's back is facing the camera. This will be discussed later in section 7.4.

Second, we have observed that, in general, sound is considered to be an acceptable resource that might be used to support parents with supervising children using the PChCT tool, but to what extent might using sound to represent activity be pleasant?

To examine whether the sound might be perceived as a fair report of activity we used questions that explore the possibility of obtrusive or disadvantage user issues. For instance:

- Do you consider there is any disadvantage with the sound provided with these interfaces?

Parent (3.10y) – *“the sound will be always the same beep, beep...” “...”sound should be active only with alarms (I’m thinking in something similar as the car’s alarm)”... “However, if not sound to general activity, then I cannot realize when the child is in movement.”*

This parent seems to perceive some obtrusive elements with the awareness sound. However, the parent struggled to decide whether to continue with sound or to turn it off – the latter might be more of a disadvantage. This parent understands how the awareness sound helps to reduce continual reliance on the interfaces, but feels that having sound on all of the time might be annoying.

In terms of obtrusiveness, this parent’s argument is apparently supported by parent 0.6y who says that sound might be very unpleasant if not controlled. Parent 0.6y might want sound only for high levels of activity awareness.

Parent (0.6y) – *“it may drive you mad”... “when account for warning sound because maybe I don’t want to hear the beeps at all the time when you’re doing things... but select... you know... when there is something wrong or very dangerous.”*

The scenario used by parent 2.4 not only reflects an awareness of the sound but also suggests that the tool might be improved using a mobile phone-like approach to allow parents to configure the sound as they wish, e.g. selecting the sound type and volume level to represent awareness activity.

Parent (2.4y) – *“if you can select it at the same way as select sounds for the mobile phone, so when the mobile phone rang you know if it is a message, for example.”*

The attitudes of parents presented in this section indicate that although some PChCT facilities might be perceived to be useful, issues of unpleasantness may limit their usage. The next section explores whether parents identify time consuming issues with the PChCT’s resources.

7.3.2.2 Time consuming

This issue is mainly related to the features available in the *space* and *events* interfaces. We have seen that there are significant differences in the approaches used to present information in the *space* and *events* interfaces, and it seems that parents do not want to spend time deciphering incoming events in the *events* interface; they seem to be more interested in ready-to-consume information.

Below are some parents’ responses when we asked, for example:

- Could you say a bit more about what your preferences to interfaces are based on?

Parent (3.10y) – *“because you can immediately see the hazardous area (she is talking about the space’s interface)... because the coloured spot means the child is there and so its represents the child and perhaps I don’t need to see the room’s image if you are seeing the activity here.”*

With regard to time, this parent seems to argue that if space interface represents enough of the child’s activities, then there may be no need to invest time asking for the room’s image.

Parent (2.4y) – *“it does not tell you... go to the toy box that the child is there, you need to look for the activity, am I right?” ... “the message will not turn blue because it does identify that the child is there, true?” ... “and this is easier (now looking at the space’s room interface)” ... “I mean it is quickest than easiest, you know.”*

Similarly, this parent argues that her preference for the space interface might be due to the time demanded by the *events* interface for accomplishing a task; she seems to adopt the same position as parent 0.6y.

Parent (0.6y) – *“I think I’ll probably use the space...”... “and we’ll just have a look on whether they are... rather than actually looking in the list...”*

As with the activity representation issues, parents therefore appear to prefer the use of the PChCT’s resources which are less time-demanding, for example, causing less interruptions in their everyday activities.

Next we analyse usability aspects of the PChCT’s interaction.

7.3.3 Easy to use/learning of the PChCT’s interaction

The goal of this section is to identify any complexities parents find in using the PChCT’s resources; how they configure, for example, the awareness levels or distances. In addition, we explore the ease of use of the media-request interaction.

7.3.3.1 Configuring

We examine how parents find their interaction with the profile interface. What we mean by ease of use is not only having quick access to turn on/off any of the configurable elements but also understanding the underlying awareness concepts. We asked, for instance:

- After selecting or modifying any of the available services, was it possible for you to identify any change in the system collaboration?
- In your opinion, is the tool offering a flexible interactive mechanism when asking for information or configuring collaboration?

Parent (3.10y) – *“I didn’t pay much attention to change configuration between aware services”... “I didn’t use the aware distances”... “I’ll probably use the general activity awareness level.”*

We might infer from this user’s responses that although the approachability of the profile interface is overall accepted – *“I could consider the use of a mobile phone*

more difficult than configuring the aware services” – this parent does not want to be involved with the complexity of configuring the awareness parameters. This argument might be supported if we consider that this parent scored the user profile interface with 4 (the highest score is 5). We could therefore assume that the mechanisms that allow parents to interact with the tool may not be difficult, but the actual use of these resources to configure the system’s collaboration might have some complexity. We discuss this in section 7.4.

Parent (2.4y) – *“the use of the profile interface is not difficult...”*...*“it is easy to understand when and why aware levels could be used”*... *“but if one doesn’t need to think too much about that...”*

Parent (0.6y) – *“there are not difficulties configuring the aware parameters”*... *“probably the aware distances are the learning curve here”*

To some extent, the positions of these two parents seems to be in accord with parent 3.10y in that configuring some of the profile parameters might not represent a problem in, for instance, selecting awareness artefacts. However, there are other elements such as the awareness distances that might require some knowledge or experience from parents.

7.3.3.2 Requesting media

Up to this point, we have identified that parents were very interested in using the media interface. However we wish to know how easy they found it to use in the context of attending to household work and using the PChCT tool to supervise children’s whereabouts. One question asked was:

- Consider a situation in which you are doing any housework such as cooking or cleaning, do you think there might be a chance of looking at the image?

Parent (3.4y) – *“uh, not if using the event’s interface, I don’t think so... that’s too... but here (referring to the space’s interface)”*... *“the quickest way to upload the room’s image is from the space interface...”*

Parent (0.6y) – *“yes, I can be cooking with one hand and with the other requesting the image to see my little girl”*... *“it was easy to ask for the picture.”*

One observation is that parents may associate the *space* interface with uploading the room's picture; they have expressed this throughout the previous explorations. It is also significant that parents cannot see any problems with the use of the PChCT even if attending to any other tasks.

However, are these two apparently easy interactions with the tool also pleasant? The next section shows the extent to which parents consider their experience of interacting with the PChCT to be pleasurable.

7.3.4 Pleasantness to the PChCT interaction

In this section we explore how pleasant the use of the interactive features, profile interface, media-request and portability might be. We search for parents' feelings associated with their interaction with the tool and its adoption within their everyday activities.

7.3.4.1 Configuring

Are there any experiences of using the interactive resources that appear to be troublesome and that may have frustrated parents or discouraged them from using those features? Or is it possible that unpleasantness or complexity of using some of the awareness resources of the user profile interface might cast a shadow on its benefits?

- Which are the benefits you encounter with defining the sensor's sensitivity and the alert area definition?

Parent (2.4y) – *“well, if you do not really need to touch any of these... I mean if everything here was already done for you it could be good”...“however, I don't know, because when you realize that...that you need to select this and that (pointing to the room's stuff labelling section within the user profile interface).”*

The view from this parent seems to support our theory of unpleasantness concerning the configuration of awareness parameters. This might be associated with the knowledge and understanding required to master their use. We wonder if parents grasped the technical concepts that link the sensibility, alert distance and awareness areas resources. We observe how parent 0.6y seems to agree with the above parent.

Parent (0.6y) – *“the good thing here is that you have the chance to switch off general activity and ask for alerts only.”*

In general we would argue that perceptions of the pleasurableness of configuring awareness parameters might be influenced by the short experience that users had of interacting with the tool, and in particular by the time available to make use of the possible combinations of the profile interface’s options. We discuss this in more detail in section 7.4.

7.3.4.2 Portability

One main concern in exploring portability issues is the obtrusiveness of the tool, for example, carrying it while attending to household tasks. We present responses from parents when considering using the PChCT in their everyday activities.

To what extent did parents feel that they could use the PDA user interface without affecting/modifying their attendance to household work?

- Do you consider that this tool might collaborate with you when doing the housework and caring for the child at the same time? For instance, when you are making the beds and your child is “playing” within the living room
- Do you think there is a situation in which you could make use of the media interface?
- Consider a situation in which you are doing the any housework such as cooking or cleaning; do you think there might be a chance (time/space) of looking at the image?

Parent (3.10y) – *“I think both things can be done simultaneously.”*

This parent’s response at first glance suggests that the parent had no problem with carrying the device. However, at the end of the interview when the parent was asked if something should be added to the tool, she asked:

“Do I need to carry the PDA all of the time? Because if, for example, I’m cooking and I have not any pocket for the PDA... where could I place it? If I put it over there (pointing to the room’s space on which the microwave and sink are) it can get wet...”

This could be an indication to the degree of unpleasantness that might possibly be felt if a parent is considering carrying the tool by hand; or could we take it for granted that parents will always find a means of carrying the device?

Parent (2.4y) – *“perhaps the only issue, carrying the device, is when you are walking and at the same time pressing buttons. However, I think it is easy to get accustomed to use it. For instance, you can stop walking to make use of the tool”*

This parent appears to consider that constant use of the tool might not be a problem. To explore what could underlie her positive attitude, we asked:

- do you think this (using the tool) doesn't interrupt your doings (your household tasks)

“Not in my case... there must be many other cases, but for me, aware of what I have at home (referring to the child)...”

We could observe, therefore, that the individual needs of parenting might influence the acceptability of the PChCT. In other words, if the utility of the PChCT is clear, then parents' might consider its use regardless of unpleasantness.

Parent (0.6y) – *“ it is easy its use because it's quite small” ... “it can fit in my pocket”*

Finally, we could observe that this parent is assuming that a pocket in which to put the tool will always be available. However, this parent added:

“...other thing is that she is too small so she is all the time with me...”

In summary, we could say that the overall attitude to the PChCT's features is positive with regard to ease of use. Parents do not seem to have any problems using the interfaces or interacting with them to request collaboration, such as uploading to the media interface. There is, however, a less positive response when considering the PDA user-interface for configuration, for example, concerning the awareness distances. In general it seems that parents' interest in using, and therefore learning

about, these awareness parameters might depend on their individual monitoring needs.

The next section discusses some of the previous results, in terms of the degree of social acceptability of this type of ubicomp tool and the potential opportunities to meet parents' need more closely.

7.4 Discussion of results

The PChCT might be accepted as a tool that could collaborate with parents in the attendance to the childcare task. Throughout this chapter we have seen parents' perceptions regarding the collaborative and interactive resources that the PChCT offers to help with caring for children within the home. Particular features offered by the PChCT for collaboration and interaction were explored by parents and their responses have been used as a measure of the acceptance of this kind of ubicomp tool. Parents' attitudes were explored across the four usability categories: practical worth, applicability, ease of use/learning and pleasurableness, as defined in chapter five, section 5.4.

This section discusses whether or not less useful or usable PChCT elements might have a common problem, and if it might be possible to change these perceptions by any improvements or enhancements to the PChCT. We used two approaches: firstly, we explored associations between those elements which were either less useful or usable according to parents. We use table 7-3 as a reference to discuss the PChCT-usability, which summarizes parents' apparent feelings about the PChCT tool; secondly, we explored potential improvements to some of the tool's resources in order to increase potentially parents' acceptance of the PChCT.

The level assigned to the tool resources within table 7-3 represents whether one, two or three parents seemed to consider the PChCT's features useful or usable. Section 7.4.1 discusses less useful and usable features while section 7.4.2 considers what might be seen as desirable improvements in these resources.

		Usefulness + usability			
PChCT's features/resources		Practical worth	Applicability	Pleasant	Easy use/learn
Collaboration + Interaction	Interfaces	Space	H	H	H
		Events	L	L	M
		Profile	H	H	L
	Deliveries	Txt-message	L	L	M
		Visual-space	H	H	H
		Media	H	H	H
		Sound	H	H	M
	Services	On-demand	H	H	H
		Digital-album	M	M	L
		Activity-aware	M	H	M
	Request	Media	NA	NA	H
	Configuring	Aware levels	H	H	H
		Aware distances	H	H	L
		Aware services	H	H	M
		Labelling stuff	H	H	H
		Sound	H	H	M
	Portability	Size, weight	NA	NA	M

Table 7-3 Parents' perceptions of the PChCT's usefulness and usability

L=low, M=medium, H=high

7.4.1 Useful and Usable

Parents seem to prefer visual resources to plain text. For instance, the *space* interface is preferred to the *events* interface mainly because of the lack of visual elements of the *events* interface. This section explores whether or not additional issues such as time-demands or troublesome interaction might be affecting parents' attitudes.

We have already argued that parents consider their time to be valuable. The *events* interface is not rejected by parents outright, but considered to be time-demanding. Within the exploration of the four usability categories in relation to this interface (table 7-3), we observe that it is considered fairly easy to use; however, parents are not pleased with its use. Parents commented that they found difficulties with both the identification of activity and the uploading of room's image. These two elements might affect parents' perceptions of its usefulness. We may recall that parents identified this interface as a history of children's activity from which they could recover and review recent activity, but if the messages do not resemble real activity

and the process to upload the room's picture is long-winded then interest in this interface can be dismissed – see the following comments from parents:

Parent (3.10y) – *“I’m so lazy to being pressing buttons... so selecting something from here (referring to the event’s interface) or try to get something...”*

Parent (2.4y) – *“You received a message, and the message will not turn blue...” ... “you need to find the activity-event because here you are not informed.”*

Parent (0.6y) – *“so... then if it is was actually that the child has touched it... the appliance, does it say something different? Or does it say close all the time?” ... “but it’s sending something than just saying they’re getting closer...”*

These three comments can all be linked to time issues. The first two seem to imply that time is needed in order to find the most recent event and then additional time is needed to request the room's image. The third might be associated with the time the parent needs to spend trying to identify the precise context in order to interpret the activity message.

With regard to complexity, parents sometimes avoided using awareness parameters due to the apparent learning curve (see section 7.3.3). This does not mean that they consider these parameters to be useless, but it might be the case that parents avoid them because they have forgotten the particular use of these elements during the interview session. For instance, consider the next quote from parent 3.10y applying some of the technical concepts given during the introductory section, during her hands-on experience:

“Ok... so let’s see... here what I’m configuring is asking for any activity occurring around the red line... uh, ok... but I want to be reported for any activity occurring here (pointing to the general activity area)... if I ask for this type of activity (pointing to the alert sub-service)... so I’ll receive what is happening here (referring to the alert area) but yellows (again referring to the alert activity)... uh, ok, and here it is on... (Pointing to the warning sub-service)...and here, I can select what I want to be aware of (referring to the stuff’s labelling section)... and then, if I want to see the

picture? So I can switch to here (selecting the space interface) and then I request for the picture...”

What we want to note is that immediately after being given the explanation of “how to use” the profile interface, this parent appears to remember most of that information. But it was not recalled at all during the interview session; observe the parents’ uncertainty when they were asked: *did you find any benefit using the sensitivity or the threshold parameters?*

Parent (3.10y) – *“What the sensitive parameter is used for?”*

Parent (2.4y) – *“well, what you have said is true ...it does bother you less...”*

Parent (0.6y) – *“yes... this is the distance, isn’t it? And I got a bit confused with this one, what sensitivity does?”*

So the knowledge and understanding required to make use of the awareness distances seem to be a factor limiting the perceived usability of the user profile interface.

Two other resources that are not fully accepted by parents are the sound and awareness services, in particular the digital-album service. Sound seemed to suffer from two constraints, one associated with its social obtrusiveness and the second with the resources available to manage it. Obtrusiveness is related to having sound all the time, even though parents might agree that the benefits outweigh the problems. Better management of the sound is an issue we dealt with in the next section. We suggest that issues about awareness services may be associated with particular contexts for use and the individual needs of the childcare task. In particular, we believe that, as with the panel survey responses, the child’s stage of development affects the perceptions of parents; this is also discussed in the next section.

7.4.2 Desirable – acceptable

This section considers whether or not parents might use this type of ubicomp tool. Throughout this chapter we have seen that parents perceive strengths and also some weaknesses in the approach proposed for this type of supportive design. In previous sections we have discussed issues that seem to be associated with the PChCT’s

usefulness and usability. Here now we also explore what might be identified as the desirable facilities that parents might expect from the tool and how the PChCT might be improved in order to match their needs. We discuss first the social contexts that might reflect support desired from the PChCT, and section 7.4.3.2 discusses the improvements that parents would like to see within this type of ubicomp tool.

7.4.2.1 Social context of PChCT usage

From our observations it seems that the perceived usefulness of particular elements of the PChCT tool appears to be associated with the particular context of use in which each parent imagines herself (see section 7.2.1.3). We could relate parents' usefulness and usability criteria to their activities when attending to childcare tasks. Our argument is that, as in the panel survey study, there may be some aspects of children's physical and psychological development that might affect the PChCT's acceptance. To exemplify this, we consider comments describing the overall position of the PChCT's use within the parents' everyday life. Each comment is collated from the usability study's questions on whether a potential use for the PChCT might be found.

Parent (0.6y) – *“I found the tool useful”... “especially if you are a single parent”... but I have not an idea, if I will ever leave my child on her own as there is always someone looking after her”... “When she gets older, I will probably bring her with me to the kitchen”... “I agree that accidents occur in seconds...”, “...that you can not always be with the child”... “If she gets older and starts moving around and is not with me then I will probably use the tool.”*

This parent, although believing that some benefits can be gained from the different collaborative resources offered by the tool, cannot imagine herself actually needing to use the tool. The fact that her child is not yet walking or crawling seems to be one factor in having less demand for parental awareness, and therefore constraining the parents' expectation of finding a useful place for the PChCT tool, given the child's age. There are nevertheless some scenarios used by the parent to imagine the way that she could make use of the tool as the child grows up, or if she were a single parent.

Parent (2.4y) – *“There are children who are very quiet or passive, and who you can leave playing in a safe place; however, there are children who are very active, like mine, who need supervision most of the time...”*... *“For instance, I will probably be interested in recording everything and not only risky or hazardous activity”*... *“So you do not need to rely on questioning the child about what happened.”*

Within this parent’s experience, it seems that the tool might be considered to be very useful. The use of space and the exploratory activity that characterize this child, as reported by the mother, are the two main criteria used by this parent when considering the usefulness of the PChCT tool. There seems to be an additional opportunity for the PChCT to support this parent, considering that her child might not be sufficiently skilled yet to communicate fluently with the parent.

Parent (3.10y) – *“I can see the use of the tool to, for example, find out what are your child’s whereabouts without shouting, where are you? What are you doing?”*... *“you see what is happening or what the child’s activities are... so why I should go downstairs if I saw everything is fine.”*

This parent pointed out how the tool might support her with the childcare task if, for example, the child is on a different floor. Given that this child can fluently communicate with the parent, we would assume that the possible benefit to the parent from the tool is in avoiding interrupting her activities. There seems to be an additional element in the parent’s feelings, that because of their child’s age they might need rather less supervision.

From these scenarios, we observe that the child’s development is a factor influencing the kind of use that parents envisage for the PChCT tool. The next section analyses the features that parents found acceptable from the PChCT and to what extent its collaborative resources might meet parents’ needs.

7.4.2.2 PChCT acceptance

In this section, we discuss to what extent parents might consider using the PChCT after their usability experience; how changes with the childcare activities are perceived; and whether they think that the tool could be improved.

Tool support

We explore to what extent parents feel that the tool could support them with childcare and whether they might consider its adoption. To do this, we ask questions to identify, for instance, how the tool might affect their activities in caring for their children. Some of the questions used to explore these social views were:

- Do you think you would change the way you do childcare and housework if you had this? How?
- Do you think you would trust a system like this?

Table 7-4 summarizes parents' comments about using, trusting and adopting the tool.

Parent	Changes in childcare	trust	Adoption issues
0.6y	<i>I think it could be difficult to know, because... I have ever thought of monitoring ways... and I'll never leave her on her own... that much...not at this age...</i>	<i>yes... I would</i>	<i>if the system starts malfunctioning I'll surely stop using it... if you cannot trust it so much if it made mistakes saying something she didn't do</i>
2.4y	<i>I think I would be less worried... it doesn't mean changing the way of interacting with your child but just less worried...</i>	<i>at some point...at least I could try...</i>	<i>I don't know... I might be satisfied with those tool's features..., if I can test it for a while I could say more...</i>
3.10y	<i>if I saw everything is fine... the child is ok... why is should go downstairs... The disadvantage could be if you make use of the tool when you are not busy... when, for example, you are using the chat in the computer and so you could prefer to go on with your conversation rather than to spending time with your child because you can use the tool...</i>	<i>No...</i>	<i>because is something new... and as any new artefact you need to use it... you cannot adopt it at all since the beginning... a good reference is if other people are using it... it might be attractive to try it... for a month perhaps... just to check if it is useful or not...</i>

Table 7-4 Could the PChCT tool be adopted?

We observe some factors that might influence parents' feelings when considering adopting the PChCT. It might not be strange that parent 0.6y cannot put herself in the context of using and adopting such a tool if we remember that the child seems to be always with the parent or cared for by another relative. In spite of this, this parent might try to use this type of ubicomp tool to explore its social benefits. Parent 2.4y has a more positive attitude to tool adoption. We may recall that this parent considers her child to be very active, and this might be reflected in the parent's attitude. Similarly, parent 3.10y is not discarding the idea of using the tool, but she might decide to adopt it only if the tool has proved its reliability. However, it is interesting to observe her concern that the tool might adversely affect parents' attention to their children.

Thus we could argue that the perception of usage and adoption of the PChCT is again associated with the particular and personal demands of childcare.

Tool improvement

We present in this section what parents suggest or imply needs to be improved or enhanced in the PChCT. This might help to identify opportunities for the tool's resources to meet parenting needs more closely.

Interfaces: what could be improved within the *events* interface to increase acceptance by parents? From the usefulness and usability responses to this interface it seems a major re-design is needed. This might include changes to the mechanism used to deliver text-messages as well to the process of uploading the room's image. Although we could offer those improvements to the *events* interface, it is better first to explore whether this interface is needed given the *space* interface. This could help to identify to what extent re-working the *events* interface might be worthwhile.

Parent (0.6y) – *“The events... I don't know if I'd use that too much...”*

Parent (2.4y) – *“If I am in the position of taking out something, I would remove the messages.”*

Parent (3.10y) – *“If I can count with the space interface, I don't care about the event's interface...”*

We could observe that parents appear to agree that the events interface will never be as acceptable as the space interface. As well as attending to parents' suggestions to improve the events' interface, therefore, it might also be preferable to further develop this interface as a complementary resource that parents could use to access the recent history of their children's activities.

Parents also suggested that if the space interface could be enhanced to represent more activity then they might not upload the room's view so often. This is another aspect that reinforces the value of time to parents.

Parent (0.6y) – *“Because the coloured spot means the child is there and so it represents the child and perhaps I don’t need to see the room’s image if you are seeing the activity here...”*

Parent (3.10y) – *“If you can see where exactly they are in the room or close to the thing... and it can be just too good... because you can have a clearer idea or a quick look of the movement of the child and perhaps you do not need to rely at all the time with the media...”*

The parents suggested that if spots, which are used to represent children’s location and proximity, could move so that parents had a clearer idea of the child’s movements, then, they might not invest time viewing the room’s image.

The user profile interface might also be enhanced in order to help parents to understand and identify the aims of the sensitivity and threshold awareness parameters. We could first rename these parameters using terms that reflect more clearly their purpose – for example, “movement threshold” and “alert boundary”.

The sound: it appears that there are two unpleasant factors with the sound resource. The first is associated with the lack of distinctness between general-activity, alert-activity and warning-activity sounds. The second is related to its obtrusiveness. We believe, however, that the two issues might be addressed at the same time if we provided the means to select the type and configure the sound level, as suggested by parents (see the “reporting activity” section in 7.3.2.1):

The media interface: although parents consider this to be a very worthwhile resource, they suggested that it could be enhanced. They were mainly interested in a more dynamic view of the child’s activities. In particular, they suggested that a short video rather than a static picture might add value to the media interface. The argument given is that with a video, parents could identify children’s attempts or intentions and so might have better evidence to decide if they need to interrupt the household work to go to the child.

This might also be used to overcome the limited field of view of webcams. This technical limitation was present in the hands-on session, when a parent could not sometimes view her child in the room picture because the child was too close to the TV and out of sight of the webcam. With the availability of video, parents could track the child's activities and understand when the child is out of the webcam view.

In summary, this section has discussed whether the PChCT could be seen as a tool to support and enhance the attendance of childcare activities. We also explored whether the feasibility of suggestions from parents for tool improvements and how this might affect the perceptions of the usefulness and usability of the PChCT. We conclude that support needed for childcare might vary between parents according to their child's stage of development and the individual way that each parent cares for their child. In addition, it might be argued that with the proposed enhancements to the PChCT's features, this tool might offer better support for childcare tasks – for instance, reducing its time demands and obtrusiveness.

7.5 Chapter conclusions

The PChCT usability study has been used to explore parents' feelings about using this type of ubicomp tool to support them in childcare tasks at the home. Parents were introduced to the PChCT tool and its approach to collaboration in supervising children. They interacted with and explored the PChCT's facilities to support them in caring for their children. Parents expressed their enjoyment and concerns not only about the supportive approach proposed by the tool but also about how it might support and possibly change their attendance to this domestic task.

The attitudes of parents to the PChCT's resources and features were explored in terms of the four usability categories of practical worth, applicability, ease of use and pleasurableness. This in turn suggested the extent of acceptability of this type of ubicomp tool which aims to support everyday activities. For the PChCT, in particular, we could argue that the collaborative and interactive approaches used by the tool are to some extent accepted. Parents are pleased with a tool that avoids demanding too much attention from their daily work. However, there are some parenting concerns that might limit engagement with these kinds of ubicomp designs. The social constraints seem to be related to the individual characteristics and conduct

of childcare activities, and to some fears from some parents about being supplanted by technology.

Finally, although the PChCT might be considered to be a tool that could help parents with childcare commitments, its possible usage or adoption might be strongly influenced by social constraints. The usability study results show that parents accept that ubicomp tools are potential resources to support their everyday lives, but these tools might still be far from being adopted. Although it is not possible for technology to claim full social acceptance, therefore, the usability results are useful to identify new opportunities for ubicomp research.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

This thesis has put forward a novel ubicomp experience within the domestic setting. Following a framework that considers the social context alongside the design and runtime of a ubicomp system it seems possible to design more socially acceptable ubicomp experiences for the home. Social aspects of domestic behaviour were taken into account to define the degree of integration of the technology and to determine levels of collaboration and facilities for system adaptation. This helps to manage issues of intrusiveness and obtrusiveness. Two studies were undertaken to explore social acceptance of a ubicomp tool that aims to support parents with some of their childcare supervision.

Chapter one introduced the main concepts of the work, including social concerns about accepting and adopting goal-specific technology in the home and the apparent uneasiness with pervasive sensing, which is required by context aware ubicomp designs. We introduced our preliminary technical and user studies to understand how these perspectives could be integrated when designing ubicomp services for the home. This formative stage helped with the formulation of the two main goals of the thesis outlined below: -

To give a formal account of the social context to inform the collection of information about domestic activities through sensing technology and to allow the system to be adapted to current users' preferences and behaviour.

Followed by: -

To implement this framework in order to evaluate whether such a design is perceived as socially respectful of the living space and whether users feel comfortable with their interaction with such a ubicomp system to adapt levels of interaction and collaboration.

Chapter two reviewed a selection of work focused on supporting householders with respect to the integration of pervasive technology, collaboration and user interaction,

and highlighted some potential limitations when taking into account human factors of domestic behaviour in today's homes. In particular, we observed that the common overlooking of both technical and social issues seemed to be associated with the kind of collaboration envisaged, e.g. the enhancement of spaces for elders in their homes. We argued that there are other social scenarios that might not fit the social-technical assumptions of previous work.

Chapter three uses lessons from previous work to propose a framework that might help in the design of more acceptable ubicomp experiences in the home. The framework uses the human context of domestic behaviour as the pivot about which to explore the integration of candidate technologies within the home. It is also used to define facilities for collaboration and a distinct element to define user interactions, which in any case should be available at any of the system's layers: sensing, collaboration and adaptation. The exploration of the relationship between social and physical contexts might help designers to identify realistic context gathering capabilities, whereas the relationship between social and digital contexts might help with the determination of the system's awareness and adaptation.

Chapter four demonstrated the application of our framework with the construction of two prototypes, the context-aware room and the parent-child companion tool, PChCT. The first helped with the gathering of context and the second with the delivery of collaboration and user interaction. With the framework as a guide, the implementation of the context-aware room was done considering the interaction of the social and physical contexts. That is, we installed sensing technology taking into account potential issues of intrusiveness and obtrusiveness with regard to both the built spaces and the family's behaviour. The interaction of the social and digital contexts was addressed when designing the PChCT user interface. This helped to define the PChCT's facilities for collaboration and interaction. For instance, it aimed to reduce time-demanding interactions and avoid unnecessary interruptions to users' affairs.

Chapter five established the criteria used to evaluate the end-user acceptability of this kind of ubicomp tools. In this chapter we also described the design and management of the studies of PChCT. This included a panel survey and a usability study. For the

panel survey, we ran the study in a nursery setting and invited twenty parents to participate. The study consisted of a video-demonstration and a questionnaire. The video was used to introduce parents to the use of ubicomp technology to help them with some of their childcare activities; to the motivation underlying the research; and to some of the facilities for collaboration and interaction available within the PChCT. For the usability study, three parents were invited to use the PChCT. The usability study consisted of an introduction, which helped with setting the context for the study; a hands-on experience, in which parents explored the PChCT's collaborative and interactive facilities; and an interview, from which we gained feedback about experiences with and attitudes to the PChCT. Each of the hands-on usability experiences was personalized using the parent's own parent-child activity collected within the aware room prototype. Results from both studies were analyzed in chapters six and seven respectively.

Chapter six presented results from the panel survey and explored the social acceptance of this type of ubicomp system. The group-based study helped to identify and understand social perceptions of computer-based support for some household tasks such as childcare. This study examined acceptability from three perspectives: overall perceptions of the usefulness of ubicomp tools such as the PChCT; facilities offered by the PChCT to support child supervision; and social factors that might influence the acceptance and adoption of this kind of ubicomp tool.

Regarding usefulness, the results indicated that, whereas the availability of these kinds of tools to support parental activities seemed to be very welcome, their adoption might not be straightforward. Technical and social issues were identified when we asked parents about the adoption and use of the PChCT. People seemed to want to experience the tool before giving an answer about the use of it. Some fears about technology were also expressed. For instance, parents were aware of being pushed out of their "usual" way of bringing up children within their own culture.

With regards to the PChCT's facilities, participants expressed an overall appreciation of the mechanisms available to control the system's collaboration and thereby reduce the system's intrusiveness. However, some technical limitations again appeared in the understanding of concepts and configuration parameters to adapt the system's

collaboration. This in part might be attributable to lack of real experience with the PChCT. Nevertheless, from individual attitudes we observed other social factors that might influence the acceptance and the adoption of such a ubicomp tool, e.g. working parents, use of private childcare, home architecture, children's ages, child development, culture and so on.

Chapter seven presented results from the usability study undertaken with three mothers, who had a hands-on experience with the PChCT. The exploration of the acceptance to the PChCT was conducted by considering the four acceptability criteria defined in chapter five: practical worth, applicability, ease of use and pleasantness. Overall results from the usability study indicated that parents recognize that ubicomp tools might be useful to complement some of childcare activities. They liked being given some control over the system's proactive collaboration. Although individual nurturing issues were present in the parents' attitudes, they seemed to agree that tools such as the PChCT might help them to be less worried if they needed to leave children unattended while they split their time in order to complete another activity. They liked the availability of different mechanisms used by the system to convey collaboration – the space interface and sound – as they might fit in with the different circumstances in which support might be required.

Another element that pleased parents was the room images associated with the child's activity. In fact, parents asked for a few seconds of video streaming rather than a static picture as this can help them to identify the child's intentions. It was clear that time is an important asset in people's lives. Parents considered the approach used with the text-based collaboration to be time-demanding and not fitting with their busy days.

Additionally, it appeared that the hands-on experience helped parents to overcome technical problems with the configuration and adaptation of the system's interaction, an issue that was present within the group study. In general, the usability study helped to complement views gathered from the panel study. We argue that child development and the variations in parents' activities are two elements that influenced the perception of the usability of this kind of ubicomp system.

8.1 Thesis goals

The original goals of this work were to design a ubicomp experience characterized by a socially respectful approach to the accommodation of pervasive technology and which allowed users a high level of involvement in determining the system's level of collaboration.

The holistic approach of considering the interaction of technical, physical and social contexts is non-contentious as it reduces intrusive/obtrusive issues within the living space. We expected, however, that because of its less obtrusive approach the context aware room should be portable and thereby a large coverage of homes should also be possible. However, this was not possible, and the evaluation of the context-aware room was to some extent limited as a result. There is also a need to make the sensing layer flexible enough for householders to adapt/update the system's sensing infrastructure. For instance, from parents' attitudes to this kind of ubicomp tool we found that one parent wanted more sensing devices to increase the awareness of the child's whereabouts while another asked for additional environmental monitoring to increase the system's awareness and thereby reduce interruptions of the parent's activities. The context-aware room was useful, however, to study and highlight through our framework some of the domestic behaviours that designers have to explore before moving pervasive technology into the home. Additionally, the context-aware room helped to collect activity data that was used later to personalize the parent experiences with the PChCT.

The design and implementation of a ubicomp UI that mediated collaboration from and interaction with the context-aware room prototype was successful. The collaboration conveyed through the PChCT and the facilities to reduce interruption of parents' affairs were both widely accepted. Parents were pleased with the available resources of the PChCT to adapt the system's collaboration. Although we have realized how disparate different users' needs might be, e.g. due to the child's stage of development and parental nurturing "style", the usefulness of the tool was accepted by parents. Despite its acceptance, however, we found that the approach offered for the system's adaptation might affect the adoption of the PChCT.

Finally, our user studies show overall that the degree of social acceptance of this kind of ubicomp tool is promising. Firstly, parents are not rejecting the idea that ubicomp technology might be useful to support their everyday life, and in particular their attendance to the childcare tasks. Secondly, we could argue that the PChCT design appears to fulfil the configurability requirements for parents to adapt the tool to their individual convenience. We might also say that there is still a gap between experiencing ubicomp technology in realistic homes and laboratory-based environments.

8.2 Contributions of the work

A novel ubicomp in-home experience aiming to support parental activities.

In chapter two we observed that typical ubicomp experiences have been undertaken under controlled environments, i.e. laboratory based settings. While we recognized that these contexts are useful to explore human-computer interactions because physical and social issues can be isolated, we decided to recognise the challenge of designing a ubicomp experience within a real home. Moreover, whereas most of the previous work has been focused on supporting a particular social context – the safety and comfort of the well-being of elders – we chose a different social need with the design of a tool to support parenting activities. In those terms our second contribution is:

The definition and implementation of a framework that uses the social context as the central element to design domestic ubicomp experiences.

We explored and defined the interaction between the social and physical and the social and digital contexts as the two keys to designing socially acceptable ubicomp experiences. The social-physical element can be used by designers to explore constraints that need to be addressed in order to define the type and degree of technology that can be integrated into the home. This is demonstrated through the implementation of the context-aware room prototype. The incorporation of technology was done with consideration of the social and individual aspects of domestic activity and behaviour, such as use of room spaces, aesthetics and obtrusiveness with regard to the built environment. The social-digital element can guide designers in addressing intrusiveness issues with regard to everyday family activities. This defines the systems' collaborative approach, which includes the

conveying of information and possibilities for user interaction. The parent-child companion tool was designed as the means used by the system to deliver collaboration and through which the user can interact with the system. Visual, text and sound based facilities are used for reporting children's activities. In addition, there is the aware room picture that users can access to complement this collaboration.

Social studies that inform the HCI research community about the social acceptance and potential adoption of ubicomp tools to support parenting activities in the home.

Individual and group studies were undertaken to explore parents' perceptions and attitudes to ubicomp tools that might help with some of their parenting tasks. The group study gives insight into whether parents perceive or identify needs for tools that could support the childcare tasks, and also about the extent of intrusiveness that might exist with different cultural ways of bringing up children (e.g. fears to technology affecting social interactions). The individual study gives insight into parents' views of whether the system's collaboration could be useful without disrupting their daily activities.

8.2.1 Dissemination

Elements of the work contained in this thesis have been published in two workshops to date [Martinez et al, '06] and [Martinez, Greenhalgh '07]. The first publication presented the potential application of ubicomp technology to support some of the parenting tasks in the home, and described the proposed approach to supervising the child's activities through the context-aware room and the Parent-Child Companion Tool prototypes. Emphasis was given to the commitment of time and effort that is necessary both to keep a child safe and to help them to develop, especially if considering the already-heavy workload of most householders. The second publication shared our experiences in addressing the physicality issues around the integration of ubicomp technology within realistic homes, and the extent to which it might alter or affect the nature of the social space.

8.3 Implications for design

We argued that by considering a design approach that includes the technical, physical and social contexts we should be able to overcome some of the issues found in

previous work. There are still some concerns about the ultimate convergence of these three elements.

8.3.1 Ubicomp Technology

The exploration of sensing technology helped to identify sensing devices that were appropriate for the design of a tool for supporting parental activities. Beam-break sensors allowed the identification of adults and children, which might require a much larger scale of sensors and complex information processing if using a different approach. While we could argue that we succeeded with the beam-break sensors, there were more issues with the motion and proximity sensors, detailed in appendix B. From the motion sensor we expected to get more meaningful information, such as the direction of the child's movement. This was not possible due mainly to technical issues with the sensing capabilities of this technology, limited sensor coverage and signal variability with environmental thermal changes. With regard to the proximity sensors we realized that changes in the environmental illumination strongly affected this sensor's behaviour, so, it was not possible to rely completely on the sensor readings. In the case of the motion sensor we decided, therefore, to use it as a binary sensor, to determine whether there is activity at the centre of the room; and with regards to the proximity sensor we included parents' participation to reduce the uncertainty/ambiguity from this sensing technology through the sensitivity configuration parameter within the PChCT.

Although we established an acceptable use of these technologies, there is still the open question of whether or not we chose and exploited the best technologies.

Physical Spaces

Our initial cupboard prototype taught us that the incorporation of technology within home spaces or artefacts could raise social issues. Despite the usage of a relatively few sensors within the context-aware room their accommodation was not easy. Firstly, the specific allocation of sensors to artefacts has an implicit social factor. For instance, the positioning of beam-break sensors on the door frame is determined by the children's height. However, considering the TV set the sensor cannot go in the centre of the TV screen. Or if tagging radiators, we should think about how potential obstacles such as sofas could affect sensing. Secondly, cabling paths are difficult to conceal and methods of fixing sensors to artefacts can be highly intrusive. The

accommodation of the motion sensor at the centre of the room and the webcam in one of the corners raised issues of aesthetics and cabling paths. The existence of a centre light allowed the installation of the motion sensor, but cabling it to the host sensing board required the use of tape on the ceiling and walls. In the case of the webcam we had to place nails in the corner to create a point from which to attach this device. We reduced its weight by taking out the plastic holder and tapping cables to the wall. These issues reduced our options for replicating the aware room prototype into other houses.

Social contexts

Designing for and with people is important for domestic ubicomp experiences, but unfortunately difficult to achieve. Firstly, there are many different ways in which householders manage and run their homes, and each particular context might demand specific support. From the social studies with the PChCT there appear to be some fears about technology, and parents are concerned about being shifted out of their parental role. Nurturing children within different cultures is also relevant. We identified parents who argued against using technology; others for whom low levels of supervision with the PChCT meets their needs; and parents who wanted to be aware not only of proximity to artefacts but also environmental measurements that might make awareness and collaboration more precise.

Secondly, there are unexpected events that might be difficult to address. For instance, simple activities such as the pulling/pushing of a pushchair give rise to ambiguous or uncertain events in the beam-break sensors. The re-arrangement of the sofas can obstruct the performance of the proximity sensors. Additionally, ways of attending to household work within different cultures – such as the drying of clothes using radiators, which obstructed the proximity sensors. Other significant changes might include the upgrading or replacing of artefacts – a new TV set or a more comfortable armchair, for example.

Finally, within chapter four we described our initial ambitions to deploy sensing technology in both the living room and the kitchen. However, technical, physical and aesthetic issues limited this implementation. Because of the small dimensions of the kitchen, the ambiguity from proximity sensors was considerable: there were always

close objects reflecting outside illumination changes (caused especially by changes in the weather). The motion sensor was also more exposed to thermal variations due to the activity occurring within the kitchen.

Beyond doubt aesthetic issues are present in any attempt to move pervasive technology into the home. The seamless integration of technology with the everyday activities therefore represents a huge challenge for domestic ubicomp designs.

8.4 Acceptability of the design framework

The design of context-aware experiences for domestic settings is challenging. Location and user's activity are two important elements that determine to some extent the quality of ubicomp collaboration, but the challenge is to accommodate sensing technology with a minimum disruption of living spaces. In the previous section, we discussed some of the technical and social issues addressed along the implementation of the design framework proposed in this work, and in particular with the implementation of the "Context-Aware Room" (CARoom). This section is included as a reflective evaluation of the design framework as a whole, which may offer insights to the extent to which its utility can be projected to the design of other domestic ubiquitous computing experiences. We first present the rationales underlying our design framework, and then discuss whether the approach suggested by our framework to the management of the social-physical and the social-digital contexts can be perceived as acceptable.

8.4.1 The rationales

We argued that previous domestic experiences with ubicomp technology overlooked the social context of human activity within living settings, and that there is an overuse of the designer criteria to lead the design and implementation of HCI experiences within the home. Others [Dourish, '04] argue that some context-aware designs have considered a static human behaviour and that computation has not been made sensitive and responsive to its setting. Thus, although the home of the future considers the support of the inhabitant's everyday activities, we cannot take for granted that proactive systems will always fit into the nature of social spaces of today's homes.

Our framework suggested that the exploration of novel applications of ubicomp technology for the home should take a careful consideration of the intersection of physical, social and digital contexts. We noted from the literature that ubicomp applications do not often take into account the management of these three contexts to build up less obtrusive user experiences; Some [Oulasvirta, '04] argue that few ubicomp applications have succeeded, because use scenarios have not been based on holistic understanding of society, users, and use situations. Our design framework specifically assumes that it is the social context of human's behaviour within the home which should lead the design of technology-based collaborative systems.

The framework was built then upon the consideration of the following premises:

- The framework considers the design of ubicomp experiences in today's homes.
- The framework considers the design of domestic experiences for everyone, though the underlying motivation focuses on the support of families with young children.
- The framework supports the design of location- and context-aware collaboration, information from which is meant to be unobtrusively collected.
- The framework explicitly includes the user participation to adapt collaboration.

The next sections discuss the acceptability of the management of these contexts - physical, social and digital.

8.4.1 The management of social and physical contexts

The movement of a large scale of pervasive technology into the home brings valuable opportunities to support householders, but also increases technical and social issues. We argued that if technology seeks to find a place within everyday domestic environments it first needs to be accepted by or negotiated with users. Our framework explicitly considers social factors of living spaces as an important issue when accommodating candidate technology within the today's accidentally smart home [Edwards, Grinter, '01]. It is known that there is not an infrastructure for pervasive technology in today's homes and that the home of the future is still quite far from the reality. It is relevant, therefore, to take into account issues of physicality of living spaces.

Technology and social issues will be more remarkable when collaboration target healthy families. We argue that this group of householders can be very sensitive about the degree of collaboration and the intrusion of technology. For example, [Dourish, '04] argues that the family's behaviour is dynamic and that ubicomp technology can have an important impact on the family everyday activity.

The implementation of the ubicomp tool to support parents at the home showed that technology not only can affect the aesthetic of physical spaces but also the culture activities that shape the home. For instance, we were politely asked to remove sensing technology from the cupboard doors. This manifestation of how technology can affect domestic activity was also clear with the sensor attached to the radiator which was sometimes blocked with clothes. There are also other experiences from which householders have raised issues about the potential danger that the installation of pervasive technology can represent for young children or even pets [Beaudin et al, '04].

Thus, our framework can be used to point out that the dynamics of the human activity is an important element when deciding *what*, *where* and *how* technology is moved to the domestic environment. For instance, the implementation of a "hazard-free" room across different houses has to deal with issues of physicality of built resources and domestic activity.

We can foresee, however, a downside for the strictly following of the framework regarding the accommodation of pervasive technology in the home. As argued previously the context representativeness of the inhabitant's activity depends on sensing technology. Therefore, constrained sensing environments can compromise the implementation of potentially domestic collaboration, as discussed in the next section.

8.4.3 The management of social and digital contexts

The framework considered two approaches designers can use to determine the collaboration of domestic ubicomp systems. The first is in regard with the exploration of the potential implementation of aware services and their social impact within the everyday activities. The second is in regard with the user participation

within the runtime of a system to adapt collaboration. That is, our framework remarks that context representativeness, and hence collaboration, should be pertinent to people behaviour rather than to sensor signals [Oulasvirta, '04].

Different users needs different level of collaboration

The behaviour and diversity of householders are importance elements to design collaborative services. As accounted by [Crabtree, Rodden, '03], ubicomp designs should take into account individual needs. Our framework goes a step further and suggests that instead of tailoring services, but provided that technology has addressed issues of physicality, systems should offer adaptive collaboration. Information from the sensing layer should be maximized, different approaches should be implemented and users can decide which services and which degree of collaboration meet their current needs.

Consider the scenario for the implementation of a system that offers “hazard-free” spaces in the home. That the system allows us to track the user’s location and activity from both the kitchen and the living room. That the context information allows us to be aware of situations such as:

- Unexpected use of the home’s spaces – bathtub, hallway, living and kitchen rooms.
- Risky user interaction with artefacts – fireplace, cooker, electric sockets, cupboards.
- Hazard activity in the environment – gas or liquids leak, extreme ambience temperatures.

Different context-aware services can be implemented to make the home’s room “hazard-free”. These services can be made available to users but then the system should let the end user adapt the degree of collaboration that meets his/her current needs. For instance, the user might only want collaboration when the cooker is on but not from activity nearby the radiator. Before going to the next section which discusses how our framework includes user participation with ubicomp systems, we present how collaboration was implemented for our monitoring system.

In our system the living room was the key home's space to be aware of the child's activity as parents often consider it the place in which the child behaves while the parent attends other of the household tasks. Although the activity-monitoring approach can be extended to the other homes, we realized that the collaboration implemented do not fully meet other parental needs. For instance, one of the parents who experience the system wanted collaboration with the monitoring of her child around most of the house spaces. This might be an indicator that inhabitants could be open to negotiate the incorporation of more pervasive technology if the benefit of collaboration is clear. This utility factor can also be clear if we want to use the activity-aware living room for the kitchen. For example, elder people might require from the tool not only support with the monitoring of the use of rooms but also automation resources to take control over artefacts and offer hazard-free spaces.

Adaptation of collaboration

The framework promotes designs that minimize interruptions with the everyday user activities. To that end, it suggests that collaboration must consider mobile people; that user interaction with the system should be free of complexities; and that user should be allowed to *control* proactive collaboration.

Mobile collaboration is important because people can carry on with their everyday tasks. However, true mobile collaboration could imply the use of pervasive devices such as tactile displays or speakers; something hard to accommodate in today's homes. Nonetheless, the suggested approach to offer a variety of collaborative resources – visual, text-messages, sound and pictures – seems to be respectful of the user's doings. Also and as suggested by the framework, interaction with the system must be without difficulties if we want to minimize fears of ubicomp collaboration [Meyer, Rakotonirainy, '03].

Our framework recognizes that people have the ability to lead meaningful lives [Ouslavirta, '04] and, therefore, it considers the user participation with ubicomp systems to negotiate the degree of collaboration that meets their current needs [Brodersen, Kristensen, '04].

We believe that the approach used to provide resources to adapt collaboration from the CARoom can be extended to any other ubicomp domestic system. Users could disconnect bedrooms from the activity-aware system; or they could also define which particular space or artefact within the room they want to receive collaboration from; or they could configure how often they would accept collaboration (interruptions) from the system. The framework also suggests that users should also be allowed to configure the sensing layer, which we noted is hard to achieve in today's homes.

Utility versus socially “acceptable” designs

Our framework wants to support a better humanistic strategy, instead of technology-driven, to design technology-based experiences in today's homes. However, there is still a debate about whether the utility of ubicomp services could overcome our concerns about the integration of pervasive technology into the domestic context.

More sensing technology could mean: more environmental information, higher level of the system's awareness and perhaps the enhancement of collaboration.

Sensing information – this could help to have a more accurate representation of the user activity and his/her surroundings. For instance, sound, light, temperature, and other environmental information, can be used to get a clearer representation of not only how but also why people use home's spaces. Is it warmth? Is someone listening to music while exercising or cooking? Additional sensing technology can help to have a larger coverage of monitoring. One of the parents who experienced our activity-aware system had would like to extent the monitoring of her child to other of the house spaces.

Context awareness – richer contextual information helps to increase the reliability of the system's collaboration. We can see, for instance, the reduction of the interruptions to the user activity if the system is able to improve its *reasoning* of the degree of danger that the environment or the artefact might represent for the individual. Thus instead of just reporting that the person is close to a potentially hazard source, the system can discern whether there is a potential danger because the cooker is on, the water in the pot is boiling, and the child is playing at the very

proximity. This context of use was also expressed by one of the participants who experienced our activity-aware system.

System collaboration – besides the potential opportunity of offering mobile collaboration in the home, we might also consider agreed proactive collaboration. Consider the scenario of the “hazard-free” kitchen and in which the parent configures the system to take action on her behalf if the parent did not respond to the second alarm. In that situation and if the child is detected playing in the kitchen then the system can decide to lock the cupboard doors.

In summary, there is no doubt that the research community is being benefited with explorations of novel approaches to engage householders’ interactions with technology. However, we believe that in today’s homes, the social acceptance of ubicomp systems is constrained not only by the quality of its collaboration but also by the self-respect of the social context and as such, our design framework suggested an holistic approach to design pervasive experiences that take into account the impact with the ecology of the home.

8.5 Future work

The design and exploration of domestic ubicomp experiences is a fertile research area. Location-based and context-aware systems are two of the areas that need to be further studied in order to achieve reliable “smart” context-aware collaboration. In these terms, both the Context-Aware Room (CARoom) and the parent-child companion tool (PChCT) can be enhanced to improve their social support.

One avenue of improvement is to explore further levels of awareness using two approaches. The first approach is to explore whether or not higher levels of awareness might be possible if processing sensing data using learning-based algorithms that account for environmental factors when processing the sensor data. That is, we already identified and characterized how sensing performance is influenced by elements such as temperature and illumination, and thus we might use that information to train an algorithm to take into account such environmental changes when inferring the user’s activity. This might help to improve the level of

awareness available in the current state of our ubicomp prototypes (CARoom and PChCT).

The second approach is to collect or derive activity data from artefacts – for instance whether the fire is on or not – and to combine this with the existing CARoom data in order to explore more nuanced collaboration with parents. For example, some results from the social studies indicate that parents might want to reduce interruptions from the system if there is a low likelihood for a child to be at risk, i.e. improved reasoning about desired awareness.

Another level of improvement specifically for the PDA user-interface is the incorporation of a lightweight replay tool that would allow parents to replay information that might have been saved within the digital album of the child's activities. There are two motivations here: one to identify services that might integrate this new collaborative service – for instance, statistics of the evolution of the child's explorations around the home space, or time spent in front of the television; and the other to identify whether or not these kinds of services would be accepted. For instance, how often would parents look at the photo album to review retrospectively a child's development?

Finally, together with other research fields such as HCI, ubicomp and pervasive computing can contribute to the standardization of communication protocols that could improve the design of adaptive context-aware systems. For instance, a scenario could be considered in which every artefact and appliance integrates its own sensing technology and has a socket to connect a wireless dongle to link the artefacts with the host computer. All a householder would have to do is to attach the wireless communication device to socket of the artefact that they want to be aware of, i.e. the user builds its own context-aware environment. The middleware system in the host computer detects the new artefacts' request and registers its sensing capabilities. For example, the availability of the carbon dioxide sensor's data could be registered with the sub-system that is aware of the household safety. Using this new sensing capability the system adapts its level of awareness to control, for example, the air quality in the room. At this point we might be in a position to claim "smart" context-aware collaboration.

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APPENDIX A - THE CUPBOARD PROTOTYPE

Additional information with regard to the implementation of our context-aware cupboard prototype, introduced in chapter one, is given in this appendix.

The cupboard prototype is aware of the attempts of young children to interact with the cupboard when the parent is in a different room. Figure A.1 shows how we integrated sensing technology in a file cabinet to simulate the aware-cupboard prototype.

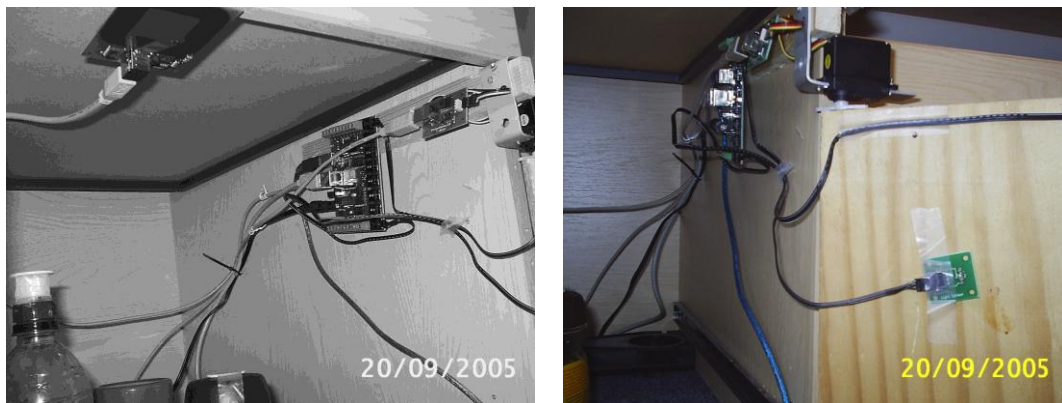


Figure A.1 The aware cupboard prototype augmented with phidget technology

We have also introduced the Equip Component Toolkit (ECT) [Greenhalgh et al, '04], which is used to process information and to explore the level of collaboration that can be offered to parents. Figure A.2 presents the ECT Graph Editor with the software components that comprise the cupboard prototype. In this we have the I/O software components that communicate with Phidget devices: PhidgetInterfaceKit (which connects to a touch and a light sensor), PhidgetRFID and Phidget Servo. Additional components are used to capture pictures (webcam), to record the cupboard events (clueContext) and to communicate with the user interface (FMRECT). The components highlighted with a thicker border are Java BeanShell components used to script some if-then rules to process context information for the aware prototype:

- IDs – map a RFDI tag with its person or object identifier.
- ChildPermit – is aware of whether or not the parent grants permission to the child.

These aware scenarios for the cupboard prototype highlight the importance of two different but interrelated abstraction levels: one for sensing technology and the other for the system's awareness. It is not a new idea that designers should distinguish between these two levels of abstraction, [Salber et al '99], [Schmidt et al, '99], [Huebscher and McCann, '04], but the problem seems to be associated with the implementation of general approaches to account for different social contexts, e.g. parental needs. With regard to the sensing layer of our context-aware cupboard we may ask, for example, whether illumination levels of different households might require technical assistance to adapt individual sensing levels, or whether the implementation of complex systems are worthwhile, e.g. the gate reminder prototype [Kim et al, '04].

With regard to the awareness implementation we need to consider how to design easily understood interactive interfaces – for instance, the association of a RFID tag with a person's name. A designer can easily implement this but users would find it difficult to understand.

In summary and to complement arguments given in chapter one, we could argue that not only the accommodation of pervasive technology in domestic settings, but also the processing of the sensing information and the conveying of meaningful collaboration to end users, are relevant elements to take into account when designing ubicomp experiences for today's homes.

APPENDIX B - EXPLORATION OF SENSING TECHNOLOGIES

The domestic ubicomp tool designed to support parents with the supervision of children's activities consists of the Context-Aware Room (CAR) and the Parent-Child Companion Tool (PChCT) prototypes. The aim of the context-aware room is to gather sensors' data from the parent-child activity whereas the PChCT is the tool used by the system to deliver information and by the user to interact with the system. This appendix is focused on describing how sensing capabilities for the gathering of context were explored and how that activity information was processed to implement the system's collaboration.

The context-aware room first identifies whether the parent is not in the same room with the child and, second, it identifies proximity between the child and artefacts. This information is then processed to report to parents about whether or not the child might be exposed to a hazard source. From here, we draw three different levels of context awareness: location at room level, location at artefact level and activity at artefact level.

Three basic sensing technologies were selected for the context-aware room prototype: beam-break, motion and distance sensors. Beam-break sensors were used to get context at the door level; a motion sensor to sense activity in the middle of the room; and distance sensors to gather proximity information in relation to artefacts. The next section therefore explores each of these sensing technologies.

Infrared beam-break light sensor and door boundaries

The off-the-shelf Infrared Beam Break Sensor, IRBBS, is a binary device used often as the trigger to alarm systems, figure B.1. We decided to use this device because its stronger signal, compared to the Phidget infrared distance sensor, gives us less concern about the sensing distance, and also because it allowed us to detach the IR diodes which facilitates its installation. One sensor was located at 40 cm height and the second at 150 cm height up the door frame; the height for the sensor location was based on the child growth chart, which considers children between 1 to 3 years to be

in between a height of 35 to 60 cm. Information from both sensors helps to identify adults from children, and also to confirm if adults are leaving or entering to one of these rooms.

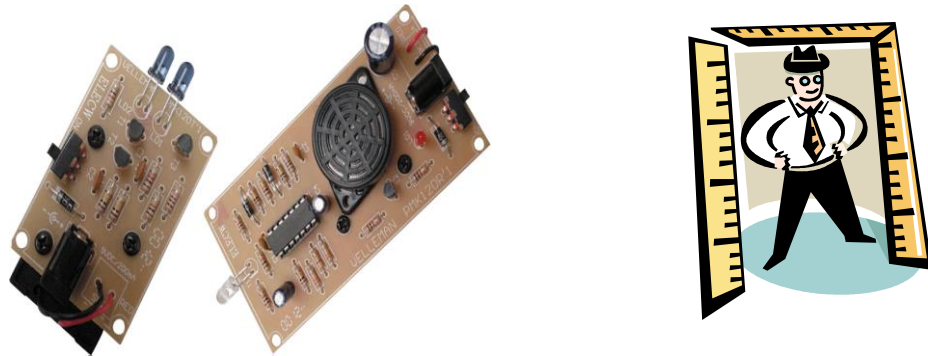


Figure B.1 Infrared Beam Break sensor used to get location context at room level

Using the binary information from the beam-break sensors and the time relationship between the timestamp of two sensors, it is possible to define the potential events that might have been triggered by either adults or young children. Table B-1 shows binary events from beam break sensors (S1, S2) and their expected time relation (Ts1, Ts2). Ts1 and Ts2 are the timestamps of S1 and S2 respectively. The hyphen under the “Event” column indicates that the sensor has been inactive for some time.

Event	Event	Output	Timestamp_relations*	User event
S1	S2	Entrée	$Ts1 > Ts2$	Adult entering to a room
S1	-	*	$Ts1 \ll Ts2$	Extraordinary event
-	S2	Entrée/Exit	$Ts1 \gg Ts2$	A child crossing the frame door at any direction
S2	S1	Exit	$Ts1 < Ts2$	Adult exiting a room

Table B-1 Output events from beam-break sensors

* “>” = “greater than”; “>>” = “much greater than”

For example, the sequence $S1 \rightarrow S2$ or $S1 \leftarrow S2$ implies events from an adult, as young children can, in theory, trigger only S2. The occurrence, in particular, of a S1 event is considered as undefined or extraordinary.

We explored beam break sensors to observe their performance, figure B.2 and B.3; for both figures the y-axis represents time in milliseconds and the x-axis represents the events. In both figures we can observe that the sequence of cross (+) and diamonds (◇) and their overlapping is an indicator of valid entering/leaving events. This very close time period between neighbours might be used to identify events from adults. So if S2 follows a S1 event we know that $Ts1 > Ts2$, and if S1 follows S2 $Ts2 > Ts1$, as stated in table B-1.

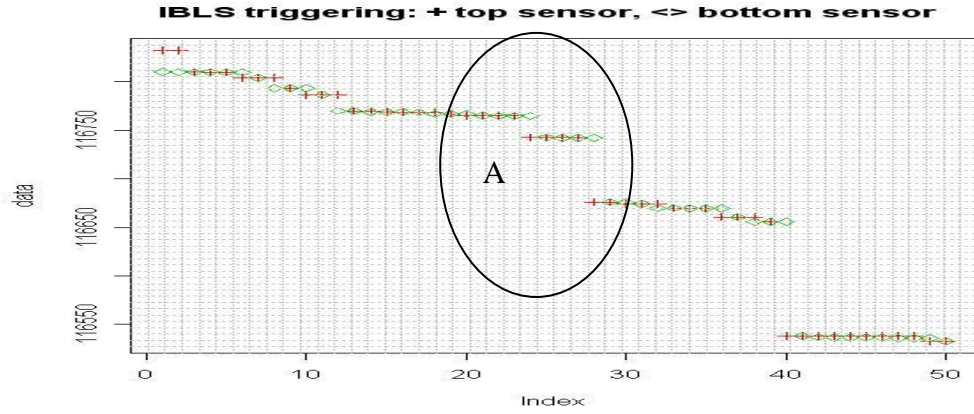


Figure B.2 Uncertain events between periods of time without sensing activity

However, figure B.2 shows that some uncertain events might appear when there are breaks of sensing activity. These periods of inactivity might occur when parents leave the kitchen and return to it some time later. We can observe that there is a sequence $S2 \rightarrow S1$ but for which $Ts1 < Ts2$. This is an indicator that the $S2$ neighbour is the previous $S1$ event and not the one that follows.

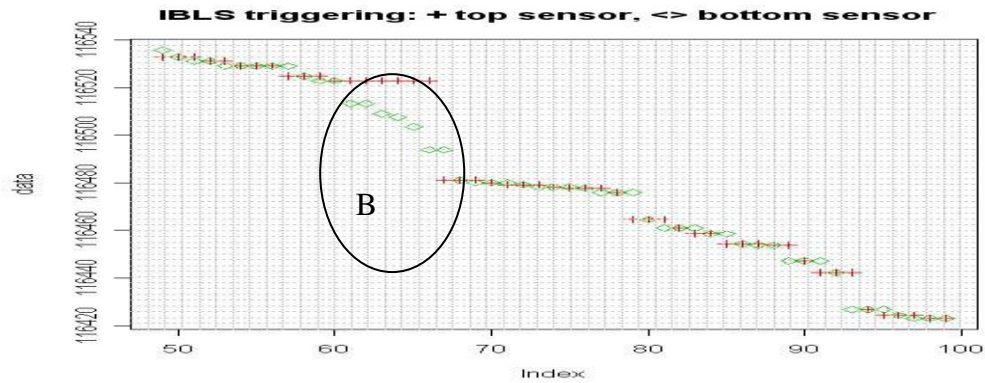


Figure B.3 Child and unexpected events

Figure B.3 shows the beam break sensor performance when simulating child events (\diamond) and unexpected events (+); sensor 2 and 1 respectively. We moved a stick up and down to trigger sensors. We realized that $Ts1 \gg Ts2$ and therefore we could use this time relation to discriminate unexpected events. With regard to child events we could again verify whether there are close neighbours and if not, then, to wait for the next event.

The problem therefore is determining the threshold time for the processing of neighbour events. To calculate this, we ran a two-day test to analyze the statistical distribution of the neighbouring delta times, elapsed time between consecutive events (figures B.4 and B.5).

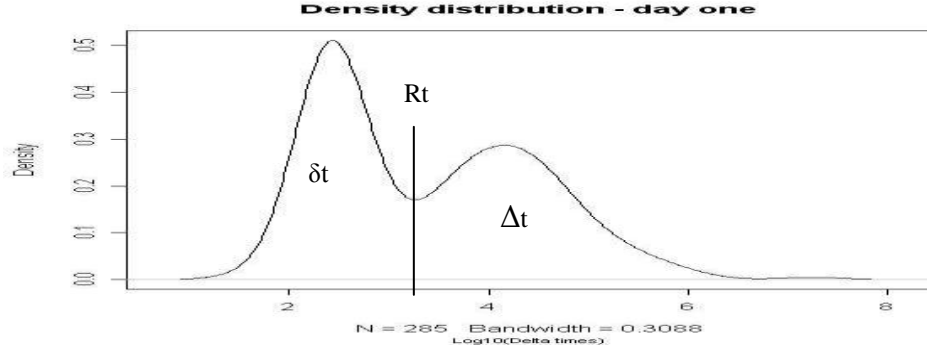


Figure B.4 Probability density distribution of the neighbours' delta time on day one

Observing activity from both days, we recognise there are two distributions, one for low delta values (δt) and the other for large delta values (Δt). δt 's correspond to times from entering/leaving events whereas Δt 's are for resuming activity after periods of inactivity. However, we must be aware that child events are likely to have Δt values as these are spared events.

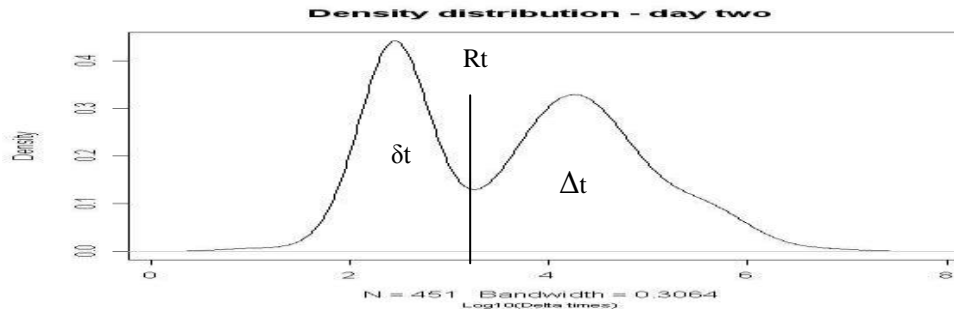


Figure B.5 Probability density distribution of the neighbours' delta time on day two

We used values around the inflection point, the joint point from both distributions (marked with R_t), to use a classification algorithm to identify the user events shown in table B-1. There are two tasks to be carried out by our classification algorithm. The first task is to identify individual (child or extraordinary events) or composite events (parents' events); this is done comparing the timestamp of two consecutive events. The second task is to identify the order of the events occurrence to identify the kind of event (entry/leave), for parents in particular.

Considering $T_{sn_{t_0}}$ as the timestamp of an event occurring at t_0 and T_{sn_t} as the timestamp of an event occurring at time t , we can state that if $|T_{sn_{t_0}} - T_{sn_t}| \leq R_t$, events' delta time is less or equal than the reference delta, then there is a composite event for these two sensors. On the contrary if $|T_{sn_{t_0}} - T_{sn_t}| > R_t$, events' delta time is grater than the reference delta, then one of the events could be an individual event.

Similarly, we can explore which sensor was triggered at time t_0 and which at time t to identify their sequence and thereby determine whether there is an entry/exit or a child/extraordinary event.

With the output from the classifier we count the number of mistakes to decide the optimum Δt . We compare the outputs from the classifier with the pictures taken by a webcam each time an event happens. This approach allows us to identify with over 90% of accuracy, parents and child activity at the door level, and thereby to infer whether the child is alone within the context aware room.

Once we identify adults from children, we can monitor activity within the context-aware room. The first element to sense activity is the motion sensor, which is explored next.

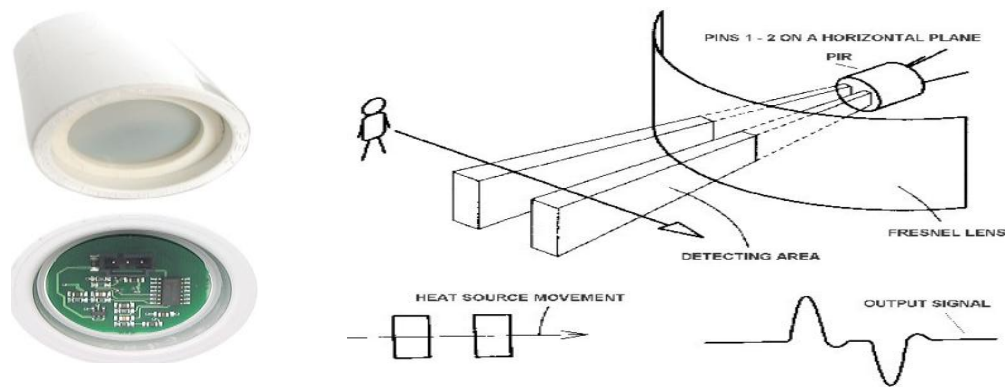


Figure B.6 GLOLAB technical notes to the PIR325

Motion sensor and activity in the centre of the room

This *pyroelectric* (PIR325) device is advertised as useful, for instance, to trigger lights, alarms or a CCTV in security systems. Figure B.6 shows the phidget motion sensor. This sensor detects infrared radiation from objects in movement and a signal is output above and below a reference point (≈ 0.500); this is the stable value when there is no movement. Sensing therefore when the output signal rises or drops out of the reference is sufficient to detect activity. For this device we wanted to identify not only presence around this device but also direction of movement, which is useful to track the child's activities.

We therefore explored the PIR sensor performance from an installation done at the home. This aimed to identify whether sensing data can be used to infer the direction

of the child's activity. To that end, eight unidirectional user's movements were recorded. Figure B.7 shows how the unidirectional movements were simulated.

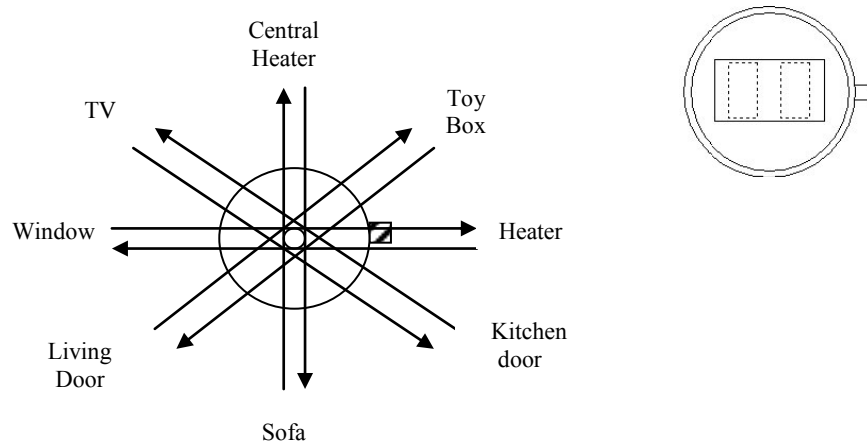


Figure B.7 Paths used to collect sensor motion activity

For each of the unidirectional movements twenty samples were recorded. From figures shown below, we will observe the way sensing data varies with most of the unidirectional movements. The apparent exception regards movement from the kitchen door to the TV. Although it was not implemented within the context processing of our aware room prototype, we believe that at some point this information could be useful to track the child's activity.

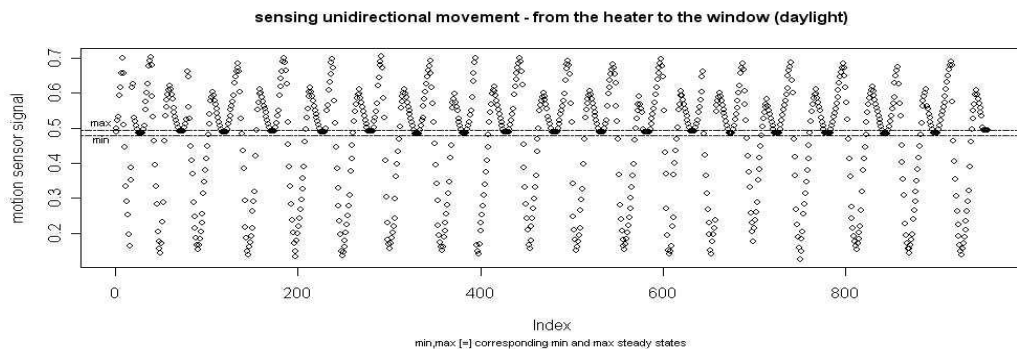


Figure B.8 Sensing data from the heater to the window

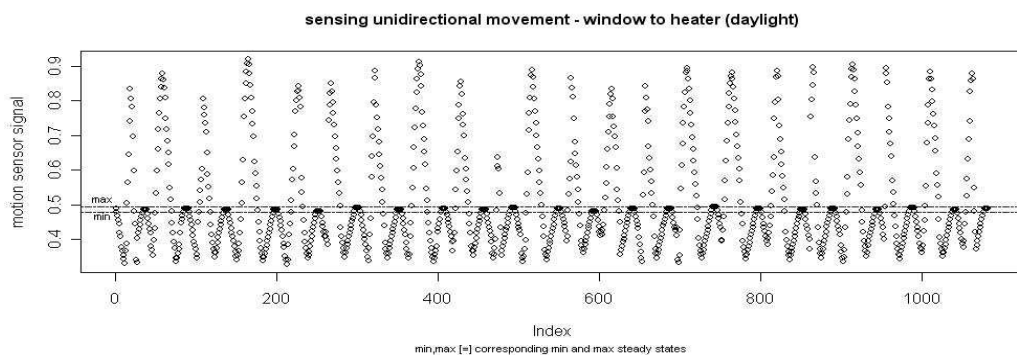


Figure B.9 Sensing data from the window to the heater

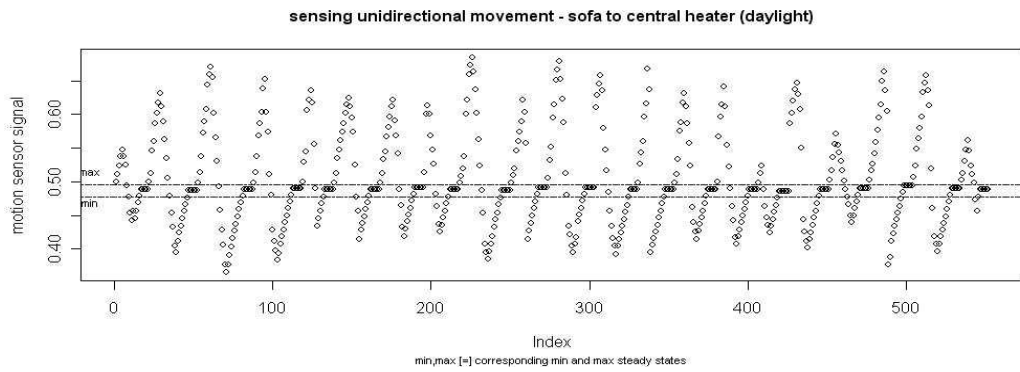


Figure B.10 Sensing data from the sofa to the fireplace

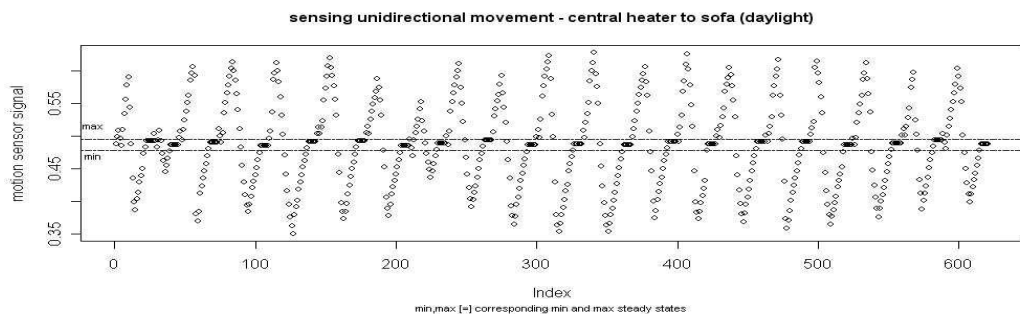


Figure B.11 Sensing data from the fireplace to the sofa

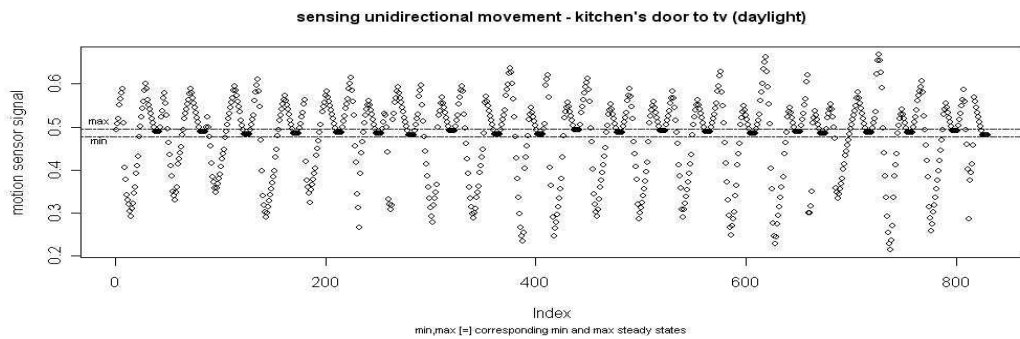


Figure B.12 Sensing data from the kitchen to the TV set

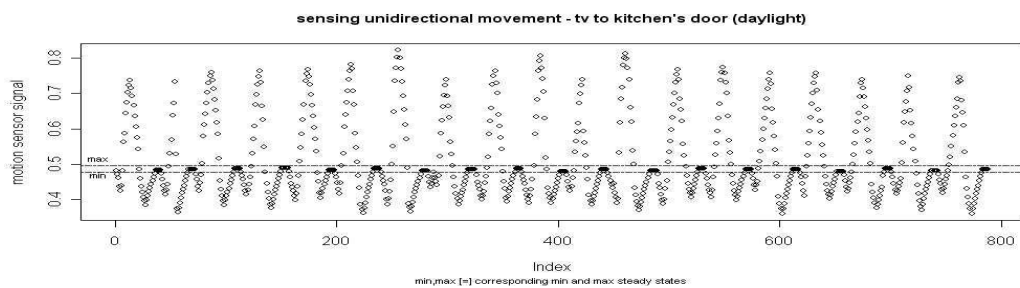


Figure B.13 Sensing data from the TV set to the door of the kitchen

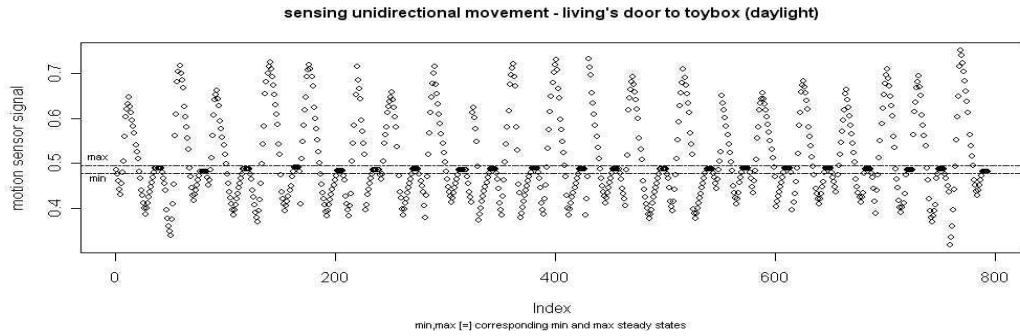


Figure B.14 Sensing data from the door of the hall to the toy box

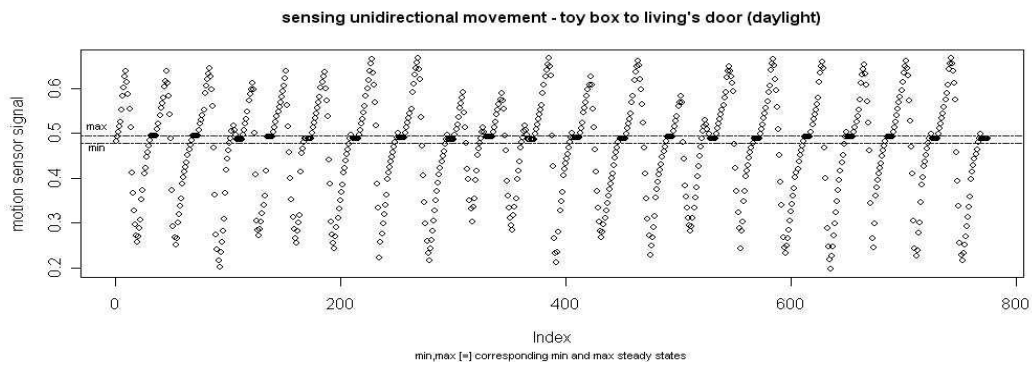


Figure B.15 Sensing data from the toy box to the door of the hall

We discarded this use of the motion sensor to infer direction because of the reduced angle of view available for sensing movement, only 10 degrees. The sensor was installed in the centre of the room at 192 cm from the floor; it gives us a field of view 33.6 cm diameter at the floor level – one meter height from the floor the sensing area is reduced to approximately 16 cm diameter. It seemed therefore that the motion sensor sensitive area is too small when we consider that there is still a large area which is uncovered by any sensor, as presented in chapter four.

The other element is that the patterns of sensing signal shown through figures B.8 to B.15 come from established paths and it is not clear whether people would use these particular paths of activity.

There are others elements that seemed to constrain the exploitation of this sensing data to identify direction of movement (such as the room temperature) and the specific orientation of the motion sensor in order to get the patterns of data depicted above. All of these factors led us to decide to use the motion sensor as a binary sensor alone to consider the presence of people.

The next sensing element refers to distance sensors which aim to collect location and activity at artefact level.

Proximity sensor and activity at artefact level

If the system needs to be aware of the user's whereabouts and of the potentially hazardous environments, it needs to know the proximity between the child and the home artefacts. We explored the sensing capabilities of a phidget distance sensor. This infrared-based device senses objects up to around 80 cm as shown in figure B.16.

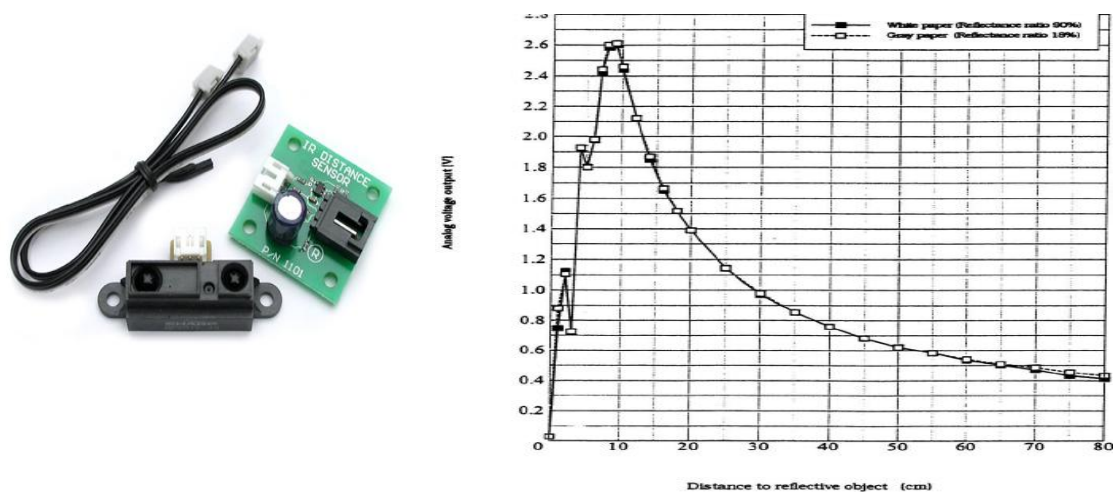


Figure B.16 Phidget sensor (left), GP2D12 Sharp infrared sensor output characteristics (right)

The phidget device scales the GP2D12 Sharp infrared sensor's output by two; i.e. output voltage goes from 0 to 5 volts.

Laboratory tests shown that this device can sense objects as close as 7 cm and as far as 130 cm. However, it was also found that some environmental factors can affect the sensing performance. Figure B.17 shows only the range from 40-110 cm as a way of illustrating how reflective characteristics of an object can add some noise to sensing data.

Figure B.17 can be used to distinguish two elements present when different reflective surfaces are behind the sensing area, which affect the implementation of the system's collaboration.

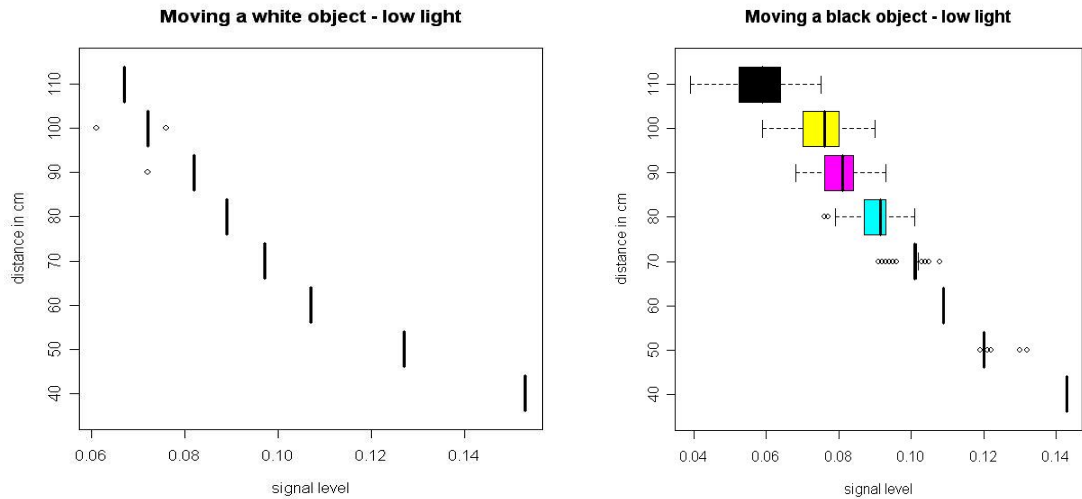


Figure B.17 Variation of distance sensor output regarding reflective objects

Firstly, objects which are low reflective will indirectly generate an unstable sensing signal. We could go further in considering sensing ambiguity if we take clothes and walls colours into account; or we could consider window size or the type of blinds or curtains used in the home. By accounting for all of these factors of the domestic life, we could consider the complexities of processing context information for this type of sensor. We could state that any change with the environmental illumination in the room will influence the performance of the phidget distance sensor.

Secondly, the direct use of the sensor's output might be not enough to collaborate with parents. On the one hand, the 40 cm distance between a child and an artefact might generate different voltage levels (see figure B.17). We might need to train a system for all of the illumination issues to identify a reliable distance-voltage relationship. On the other hand, we were not sure that parents might be interested of receiving reports from the system of every little movement of their child as it might not represent a significant change in space – for example, it might be the case that a child is stretching out at the same place, and while doing that one of his/her arms is sensed closed to the artefact. These factors again made us aware of the level of ambiguous collaboration that could be gathered from this sensing technology.

To manage this uncertainty, we therefore decided to incorporate within the PChCT tool a configuration parameter with which users could interact in order to define sensitivity for this context-collection. In addition, rather than managing changes in centimetres we used the concept of aware areas. Three areas are considered: general,

alert and warning areas. The warning area is given by the closest distance allowed by the phidget sensor; from figure B.16 we identify that it is around 10 cm (curve peak), and the upper limit for the general area is given by the maximum distance this sensor can achieve. The user participates by defining the alert point which in turn separates the general and the warning areas (see figure B.18 below):

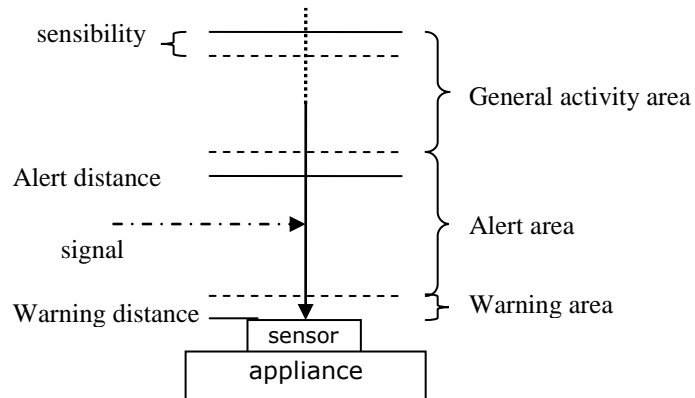


Figure B.18 The aware parameters and the aware areas definition

APPENDIX C - PANEL SURVEY RESOURCES

This appendix sets out the material used for the PChCT group study, and also the parents' responses to the open question.

Leaflet used to call for participants

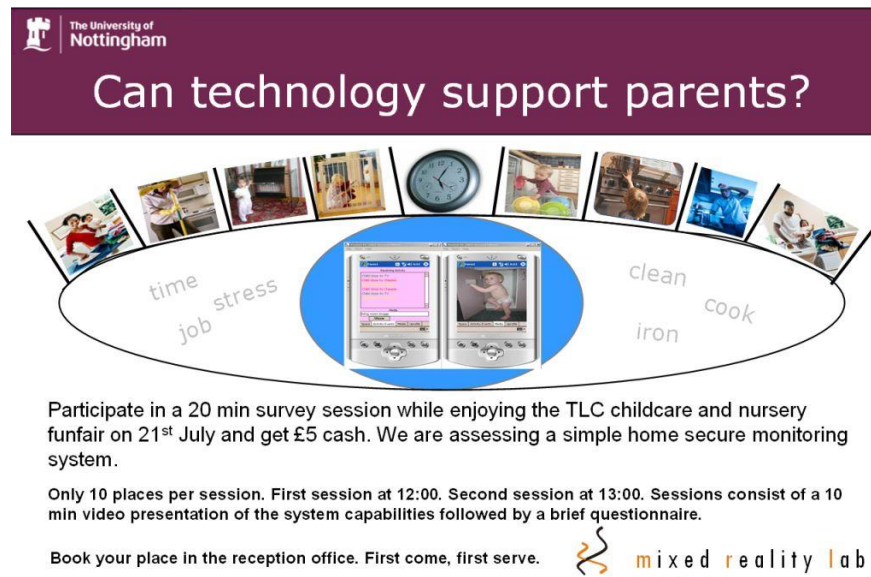


Figure C.1 Leaflet used to invite parents to participate in the panel survey

The survey questionnaire

Can technology support parents?

(introduction section)

The information gathered here is with the sole interest of identifying the strengths and weakness of the “Parent-Child Companion Tool” (PChCT). The motivation behind the system is the monitoring of young children, as newborn to under 5 are found to have the highest rate of domestic accidents.

Your feedback is very helpful for future improvements to our designs and we really appreciate your participation.

Please tell us the age of your child (or of the youngest child if more than one):

(child section) _____ years / _____ months

(main section)

For each of the following questions, please tick (✓) the closest category to your opinion.

Parent-Child Companion Tool	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Very active children are the ones that often undertake risky activities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Parents often need to keep an eye on very active children's activities	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Monitoring tools can help parents to	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

supervise children's activities					
Young children like to explore almost everything	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The tool helps parents with supervising young children	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The tool can help me identify when the child is close to potentially hazardous artefacts	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
When my child visits the GP I usually know what the source of the child's pain is	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Having a record of the child's development is a good idea	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I wish the tool could record the first experiences of my child e.g. crawling or walking	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Collaboration offered by the tool can support me looking after the child	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Collaborative services (text, space-view, sound and images) meet all of my needs for the monitoring of the child	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The identification of the aware levels (general-activity, alert and warning) is clear when using sound collaboration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
When I am cooking my child is often in a different room	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Aware levels (general-activity, alert and warning) are easy to understand when using the space interface	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
I wish to monitor the child's activities if the child is in a different room	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

(likes section)

For each of the next statements use the following scale to give us your opinion about some of the tool's characteristics.

Less liked		liked		High liked
1	2	3	4	5

Collaborative interfaces

Space interface	1	2	3	4	5
Events interface	1	2	3	4	5

Collaborative services

Text messages	1	2	3	4	5
Room-view/spatial location	1	2	3	4	5
Sound	1	2	3	4	5
Room-picture	1	2	3	4	5

Aware services

On-demand	1	2	3	4	5
Digital-album	1	2	3	4	5
Activity-aware	1	2	3	4	5

(open section)

Finally, could you tell us your views about using these types of tools to monitor children's activities. Would you use one yourself?

Why?_____

Parents' responses to the open question:

Responses	Chid's age (months)
I would consider using one but I'm not convinced that it is as safe as being with your children	NA
Seems very good to prevent my child from injuring himself seriously	8
Possibly would dependant on expense. May use some of it more than others. I like the idea of monitoring hearing and other obvious dangers to make my life easier	11
NA	12
Undecided about use. I would definitely welcome an alert for dangerous areas (ie fire), but this would not replace general healthier safety awareness or vigilance that parents should be undertaking anyway. I would not be happy having my child for more than very short period in a different room & would try to ensure this room was child friendly. However, I could see it's use if the child accidentally strayed off to another area to alert the parent	14
May consider, although prefer to keep a closer eye on the child personally	16
seems useful but not all the time	24
Feels a bit big brother-ish - constant monitoring of a child's activities may make me a nervous wreck!	26
NA	27 ^{R9}
Not for me - I found it hard to leave my daughter with an adult other than myself. So, I'd find it hard to put trust on a computer system - however if I had a large family I would consider it	27 ^{R10}
I think they are roughly useful for anyone with small children but particularly in certain situations such as - more than 1 child, children with special needs, day-care settings, etc. I would probably use this but would need to know more about it + see it in operation.	29
I will happy to use such tool to maybe sure my child is safe	31
Maybe Although some children do not leave parents alone to do anything and surely development might not be very useful in those cases	36 ^{R13}
I would use one as it would allow me to identify dangers and where exactly my child was in the room	36 ^{R14}
I would use one of the tools, it is helpful to watch my child's activities	36 ^{R15}
It seems like an extremely good idea to allow you to supervise your children while doing other things to	40
I think my child is old enough to play on her own, if we give her kind of warning beforehand she won't access or touch it, so I don't really want to use it	41
No, by the time I would have pressed button I could go & check on my child, If my child was in another room my daily chores could wait to be with them or I would get them involved. They are a good idea but not for me	46
It is interesting to be able to monitor my child but feel I would end up constantly watching the monitor	50
I would be paranoid all the time. You have to learn to trust your children. I would be too busy looking at the tool to do any housework. Your house should be safe enough for children to explore or you should keep them closer	66

Table C-1 Responses of parents to the open question of the panel survey

* Rn represents the parent's column as given by figure 6.22 in chapter six section 6.4

Survey questions grouped by category analysis

Parent's awareness of children activity (G1)

ID

Very active children are the ones that often undertake risky activities	A
Parents often need to keep an eye on very active children's activities	B
Young children like to explore almost everything	D
When my child visits the GP I usually know what the source of the child's pain is	G
When I am cooking my child is often in a different room	M

Parent's perceptions of monitoring tools (G2)

ID

Monitoring tools can help parents to supervise children's activities	C
Having a record of the child's development is a good idea	H
I wish to monitor the child's activities if the child is in a different room	O

Parent's perceptions of the PChCT monitoring tool (G3)

ID

The tool helps parents with supervising young children	E
The tool can help me identify when the child is close to potentially hazardous artefacts	F
I wish the tool could record the first experiences of my child e.g. crawling or walking	I
Information presented by the tool allows the identification of what is happening in the room	R

Parent's perceptions of the PChCT collaborative features (G4)

ID

Collaboration offered by the tool can support me looking after the child	J
Collaborative services (text, space-view, sound and images) meet all of my needs for the monitoring of the child	K
All of the available collaborative characteristics can make me trust the tool	Q
Continuous monitoring is something I would use most of the time	T

Parent's perceptions of the PChCT interactive features (G5)

ID

I like it that the system allows me to change the configuration of the awareness levels	U
The request for the room's picture is easy to understand	V

Parent's perceptions of the PChCT activity-aware service (G6)

ID

The identification of the aware levels (general-activity, alert and warning) is clear when using sound collaboration	L
Aware levels (general-activity, alert and warning) are easy to understand when using the space interface	N
Availability of the room's picture helps to clarify the three distinct levels (general-activity, alert and warning) of the aware proximity	P
Aware levels are useful to identify risky activity	S

Table C-2 Survey questions grouped by analysis categories

APPENDIX D - USABILITY STUDY RESOURCES

This appendix sets out the resources used for the usability study, including the script followed during the interview section.

The script

Introduction

First, I want to thank you for your previous participation. The information collected in the monitoring-activity session has been used to explore how designs of computational tools might support householders. In particular, we are interested on supporting parents with the monitoring of children when parents are attending concurrently other housework such as making beds, for example. Our general scenario is that the system must be aware of the child's activities when the parent is in other of the house's spaces. That is why, in the previous session, you were told to leave your child alone within the room, when possible. That helps us to simulate situations in which you and your child were in a different room. What we are assessing today, is the extent of which the tool might support you when doing the household "chores" and caring your child. In particular, we want to have a measure of the collaborative and interactive mechanisms used by the user interface, which is running on the PDA, to support you under the scenarios above mentioned.

To undergo with the user-interface test we have structured the session in three sections. First, the introduction of the user interface characteristics and its capabilities. Second, the exploration of some of the available mechanisms to configure collaboration and interaction levels to the system. Finally, a short interview will be conducted to get feedback about your experience of receiving collaboration and interacting with the system.

Introducing the system

The system consists of three physical resources: sensors, a laptop and a Personal Digital Assistance (PDA), as shown in figure D.1. Sensors are used to obtain activity from the room's environment and this information is communicated to the host computer (laptop). The host computer makes some reasoning on aware basis, and results are derived to the PDA, figure D.2.



Figure D.1 A general representation of the system's architecture: technology, computer, user interface and end-user interactions

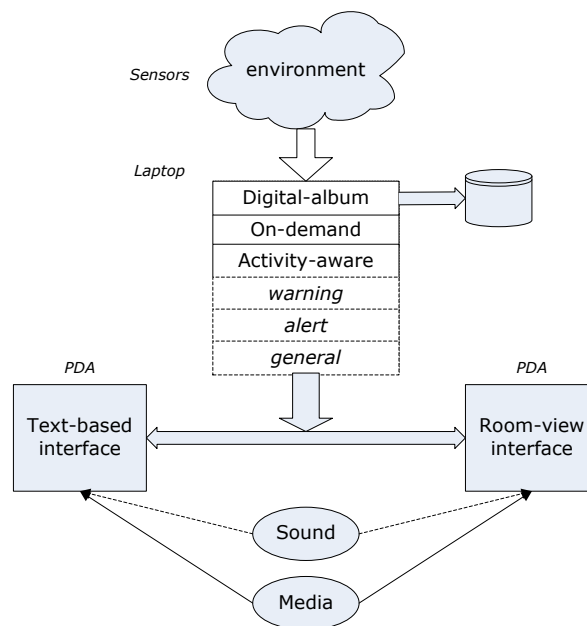


Figure D.2 Collaborative and interactive services offered to users

System services

To help parents with the monitoring of the child's activities, the system offers the following services: digital-album, on-demand and activity-aware monitoring.

* “Digital album” (monitoring at the background)

In situations where parents seek to monitor the child but not be interrupted with their activities, they can use the digital-album option. This feature records any activity occurring within the room where the child is present, but does not send any collaborative event to the user interface. If parents like to review the child's activity they could use a re-player tool either on the server side or on the mobile device.

* “Monitoring on-demand”

The system is running at the background on the server side but aware of any request made by parents about the most recent environmental activity. Thus, when parents

ask for an on-demand monitoring action, information available about the room's activity is derived to the interface from which the request was made.

*** “Activity-aware” (continuous monitoring)**

This service allows parents to monitor their child's activity on a continuous basis. To help the system with the intrusiveness issues the user is allowed to define one of the three different levels of collaboration: general, alert and warning. Levels differs each other on the awareness level and, when used, the degree of collaboration of the tool to the parent is modified. In particular, it filters the amount of messages reaching the user-interface. As will be presented later, general, alert and warning levels are delimited areas in relation with the sensing capabilities.

The selected service is processed by the system and the resulted reports are sent to the PDA. The text-based and the room-view PDA's interfaces are used by the system to inform the parent about aware activity occurring within the room. These interfaces then are the means used by the system to offer collaboration to the user.

*** Additional services**

There are, additionally, the media and the user-profile interfaces that complement the committed mechanisms for collaboration and interaction (figure D.3). The media is an auxiliary interface that the system uses to deliver the available image of the room in which the activity is taking place on request by the user. The user-profile interface is the resource the user can employ to select and configure the available services. In other words, it is here where interaction and collaboration levels for the system are defined.

Using the interfaces

Interfaces were designed in order to avoid complexities but also to maintain support. As observed from figure D.3, three interfaces are used to derive information and the user-profile interface can be used to interact with the system.

*** Room-view and text-based interfaces**

As previously stated, these are the two main interfaces used by the system to offer collaboration. Both interfaces have the same capabilities:

- Representation of activity: room-view uses coloured points to show the spatial location of the activity, whereas the text-based interface uses coloured messages.
- Media loader: the room's image associated to the activity is up-loaded to the media interface touching twice on any section of the room-view interface. Within the text-based interface, an event must be selected followed by the highlight of the living-room message and the use of the show button.
- Embedded sound: three different sounds are used to identify the three different levels of awareness.



a) room-view

b) text-based

c) media

d) user-profile

Figure D.3 Available interfaces for collaboration and user interaction

* The media interface

When requested by the user, the room's image associated to the event is uploaded to this interface. The image will be available for five seconds before the control is returned to the interface from the request was done.

* The user-profile interface

User interaction with the profile interface (figure D.4), allows the configuration for:

- monitoring services (described above)
- awareness levels for activity and its associated sound
- labelling of awareness artefacts (Living Room Stuff): which the user wishes to be aware of
- sensitivity level: helping the system to address sensing uncertainty

- e) reference to the alert distance (threshold): the bound distance the user might be use for the activity awareness



Figure D.4 The profile service interface and configuration parameters to adapt collaboration

Figure D.5 shows the relationship between the alert-distance and the sensor-sensitivity parameters in respect with the tagged appliance/artefact.

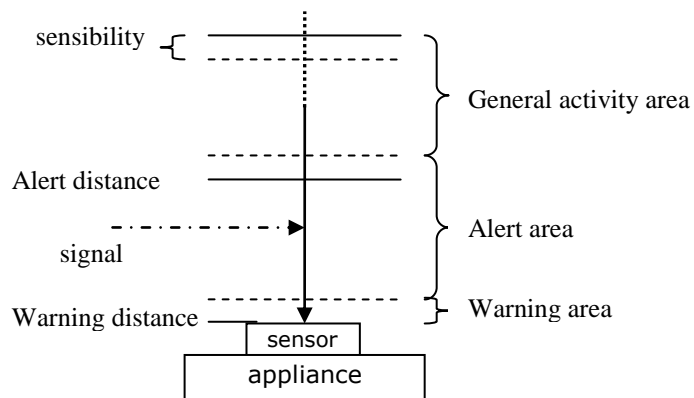


Figure D.5 The system awareness

For example, the configuration present in figure D.4 instructs the system to process environmental information, supplied by sensors, using the following criteria:

- be aware of activity occurring 60 centimetres or less in respect of
- the TV, fireplace or toy box, and radiator but only if
- the change between the previous and the current activity is at least of 10 centimetres
- when reported to the PDA use sound to complement the aware event

The interview

So, first of all, how do you feel?

<input type="checkbox"/> nervous	<input type="checkbox"/> excited	<input type="checkbox"/> good	<input type="checkbox"/> tired	
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Well, we are now in the last stage of the usability test, and for this, I need your feedback about using the PChCT. As explained at the beginning, the objective here is to explore how the current tool capabilities might fit the parent needs (in this case you), for the monitoring of the child activities. I must be clear here, that we are considering situations in which you are attending something in a different room's space than that used by the child.

It must be said, too, that there are not wrong or right responses and, therefore, I would like to encourage you to feel free of exposing whatever your thoughts might be, views and experiences of using the tool. Those will help us to improve future designs.

Interview/Questionnaire

General			
What your feelings are after using the tool?			
Was there something you found interesting?			
Can you please tell me which was or were these things?			
Was there some did you like most?			
<input type="checkbox"/> layout:_____	<input type="checkbox"/> interfaces:_____	<input type="checkbox"/> embedded resources:_____	
<input type="checkbox"/> use of the PDA_____	<input type="checkbox"/> requesting info_____	<input type="checkbox"/> aware levels for monitoring_____	
<input type="checkbox"/> _____			
Is there something, from using the tool, you like less? Something that, perhaps was less pleasant or attractive?			
YES: can you tell me a little more about it?			
NO: using a 1 to 5 scale, being 5 highly liked, what is your score for each of the available interfaces?			
RM: _____	XB: _____	M: _____	UP: _____
Could you say a bit more about what your preferences are based on?			
Is there any difference between the two main interfaces, text-based and room-view?			
Considering the two main interfaces, could you mention some of the differences between them?			
Which of the two interfaces would you prefer to use?			
Monitoring			
Do you consider that the information offered by the system is useful? That is, does it meet the aim of being a tool that helps with the monitoring of the child's activities?			
Which are the monitoring characteristics do you so consider of help?			
<input type="checkbox"/> messages_____	<input type="checkbox"/> Room view:_____	<input type="checkbox"/> sound:_____	
<input type="checkbox"/> Stuff-labelling_____	<input type="checkbox"/> media:_____	<input type="checkbox"/> _____	
<input type="checkbox"/> aware-services_____	<input type="checkbox"/> aware-levels:_____	<input type="checkbox"/> _____	

<p>Considering only the two main interfaces, room-view and text-based, which of them do you consider is more useful in terms of the information it offers to support you with the monitoring of the child's activities?</p> <p> <input type="checkbox"/> room-view:_____ <input type="checkbox"/> text-based:_____ </p>
<p>Which characteristics of the __ (liked interface) __ interface strengthen your preference?</p>
<p>Using a 1 to 5 scale, being 5 highly liked, what is your score, for each of these two interfaces?</p> <p> Room-view <input type="text"/> Text-based <input type="text"/> </p>
<p>Which are the weak characteristics to the interface you like less?</p>
<p>If response does not come, then <i>What about the activity's representation...</i></p>
<p>Were the messages (visual or textual) reflecting what was occurring within the room? For example, does the red message "The child is close to the radiator" describe the situation that the child is within the warning area around the radiator?</p>
<p>Do you consider that this tool might collaborate with you when doing the housework and caring the child at the same time? For instance, when you are making the beds and your child is "playing" within the living room.</p>
<p>Can you comment about what other benefits could you find from using this tool to support the monitoring of your child?</p>
<p>Is the sound helping with the monitoring task?</p>
<p>Does the information, either with messages or room-view, represent what is occurring within the room?</p>
<p>Are the mechanisms used to represent the information ease to understand?</p>
<p>Did you find any advantage having embedding sound with the text-based and room-view interfaces?</p>
<p>Which advantages do you find having embedded sound with the monitoring interfaces?</p>
<p>What could be their disadvantages, if any?</p>
<p>Do you consider there is any disadvantage with the sound provided with these interfaces?</p> <p> <input type="checkbox"/> No? Volume, type of sound? etc. <input type="checkbox"/> Yes? Which? </p>
<p>Do you consider useful the auxiliary interface that shows the image associated to the event?</p>
<p>What is your opinion of seeing the image of the space where the child is?</p>
<p>Do you consider this enhances the text-based and the room-view interfaces, or it does not matter?</p>

Consider a situation on which you are doing any housework such as cooking or cleaning, do you think there might be a chance (time/space) to look up the image?
Do you think there is (are) a situation on which you could make use the room-view interface?
Would you consider this tool as a communication channel between your child and you?
Do you consider the information presented by the tool allows you to identify what is actually occurring within the room in which your child is?
Does the room layout, used at the background of the room-view interface, help you with the spatial identification of activity? <input type="checkbox"/> No? Does it matter if you are pointing in a different direction, say to the opposite cardinal point? <input type="checkbox"/> Yes? What?
Interactive mechanisms
Is it easy to use the services?
Using a 1 to 5 scale, where 5 is very accessible, what is the score you can give to the user-profile interface in terms of its accessibility to configuring services?
After selecting/modifying any of the available services, was it possible for you to identify any change in the system collaboration? <input type="checkbox"/> intrusiveness level? <input type="checkbox"/> collaboration level?
Do you think there are some intrusive aspects with the system's collaboration? Think about doing some housework again, which of the services considered might interrupt you most?
Using the scale 1 to 5, where 5 is highly demanding, would you mind tell me what could be the score for each of the available services?
Considering your experience with the available services, which might fit your needs best in terms of reducing interruptions of your activity?
In your opinion, is the tool offering a flexible interactive mechanism when asking for information or configuring collaboration?
Was it easy for you to use the configuration options to establish the three aware levels?
Are the levels general, alert, warning, useful for monitoring the child's activities?
Do you consider that the aware levels matters when monitoring the child's activities? Or any activity should be monitored? (without considering risky levels or hazardous artefacts)
Are these three levels offering good awareness for monitoring your child?
From your experience with the tool, are these levels a good representation of the type of activity present within the room?
Which are the benefits you encounter with defining the sensor's sensitivity and the alert area definition?

Is the digital album service the tool is offering useful to you?
Do you find the on-demand option useful?
Closing
Was the system demanding your attention too often?
Do you feel that the system is attempting to force you to be aware?
Do you think you would trust a system like this?
Do you think you would change the way you do childcare and housework if you had this? How? E.g. - Physically checking on the child more? Or less often? - Being more or less worried about leaving the room for a few minutes?
Would you want the system warn you even if you were in the same room? Or if you were farther away?
How many mistakes (what type of mistakes) would you tolerate from the system before you stopped using it? Scale: just 1 ; 1 in 10; half... what?
In general, again, was there something from the tool that you would like to improve?
Can you comment about what you would like to have within the PChCT?

APPENDIX E – USABILITY INTERVIEWS TRANSCRIPT

The content in this appendix is the raw information as it occurred in each of the three usability interviews. This information is given as a complement to chapter seven, in which we discuss the feelings and attitudes of parents to the PChCT in the context of its usefulness and usability.

First, we start with the mother of the youngest child (0.6y) and will finish with the more mature child (3.10y). Within each of the transcripts we differentiate the interviewer with the capital letter Q and the interviewee with the capital letter R. In addition, when necessary we use parenthesis and a bold font to point out the PChCT resource or feature to which the interviewee is referring.

CHILD ML (0.6y)

Child's age: 6 months

Q: What are your feelings after using the tool?

R= *so yes... it's nice and easy to use... quite straightforward... and*

Q: yes...

R= *and... I like the way you can click on it and you can actually see... it is a natural, visual image... I didn't expect to see things that like a camera capturing things went on... but I think it is quite nice rather than you seeing... you know almost, in the writing it never says she's straight to the heater... I think if you actually look at the distance with a picture, for example, of the TV...so it would never make you go and see them... which is quite good... but it was easy to use, yes...*

Q: in general terms did you find something interesting?

R= *yes, yes, definitely... I think it could be like with the...the way you can sort out the visual I think it could be good... rather than to see the... I can't remember its name... the events... I don't know if I'd use that as much... I think I'll probably, if I use it, what we have on this **(pointing to the space interface)** and we'll just have a look on whether they are... rather than actually looking in the list... personally that would be the way I...*

Q: why? It's the easiest way to...

R= *just because it's a kind of... as suppose it's saying to be close to the heater and I think when you look at it you actually get an idea yourself of where they are... rather than to sucking it at, what these things sent...*

Q: So, the messages do not really represent what it's happening in there?

Q: if, for example, the message changes for...

R= *maybe, yes, maybe... or maybe if it gave an actual word when it is close, don't know if fixing it is too hard, whether I would say... you know, if a different two letters for different distances... so I'd say if it works... five centimetres*

away about... it's a sort of a different alert so you cannot want that them are being getting to close

Q: what if rather than being too specific with the text, considering the limitations with the PDA display, colours are used again?

R= yes, yes definitely... if say, I thought, it can be sent what could be quite dangerous with... I can imagine a kind of red or something... but it's sending something than just saying they're getting closer... keep us as thought... maybe

Q: I know you told me that something you liked is the spaces interface but...

*R= yes... that's the thing I like most... but... I think as just a parent at home I probably wouldn't necessary use the graph (**referring to the frequency graph used to exemplify one of the possible uses to the digital-album replay**)... but I think if it's used... I can imagine somewhere like in the nursery or in the school that'd been really good because there's so much now with health and safety issues ... and so if there's been an incident to school and if you could them say it to the parents... well you know we monitored this thing, distances and this is something by... you know... you can show to them to say... actually they want... need that ... when they weren't in the room... you know safety... we have a lot of schools with children coming in the lunch time when they are not supposed coming in the lunch time... so the probably really good with... for that then... if facts of things happened when they don't think they're not supervised is not our responsibility so... in that case it'll very good for something like that... I think...*

Q: Using a 1 to 5 scale, being 5 highly liked, what is your score for each of the available interfaces?

*R= I very like that one, I think it's good (**pointing to the media interface**)... so, I'll give it 5... and this 4 (**space interface**)... 'cause it sits the game representing where everything is (talking about the space interface)... I don't know whether it might be e... especially if you know the room... don't know whether it may be easier to label to what it/they are... but as suppose it's your lounge, you would know anyway...*

Q: yes, it can be adapted to your own house's room...

R= uh, ok... that would be fancy.... if it can be enhanced for...

*Well, then these here I could say 4 (**profile interface**)... and then this, that I'd say maybe 2 or 3 because I'd suppose the thing that I don't like about it is that is not specific with the distances... is that ok... that makes sense... is not.. I think if we just have a slightly... if it uses two scales maybe... if it is close... and then if it is red then they would be really close... might be more easeful to know...*

Q: ok... it maybe needs to be improved... be more representative of what's happening in the room...

R= yes, yes... if there are short distances maybe... it's to pick a heartbeat

Q: So, messages are maybe quite abstracts...

R= yes, yes... close could be... I'm touching it or it could be I'm 60 centimetres away... maybe with a slightly scale with that it might be useful... so 2

Q: Well, using the same scale but now without repeating numbers, what are your scores for the same four interfaces?

*R= ok, I'd say 5 (**Media interface**) does it one count? Because is it the general... the one used to setup things, isn't it?*

Q: Yes, even if its purpose is quite different...

R= yea, ok, let me think... I guess then, I'd say 5 (**Media interface**), 4 (**Space interface**), 3 (**Profile interface**), 2 (**Events interface**)... yes that makes sense

R= because I suppose, these two are quite similar... aren't they? But the media interface I think that would be... I think for most p... because you can actually see your child there... for most parents that could be the most effective because you can actually see what are they doing even if you need to go upstairs the loo and you already got this with you it's quite good... you know... you know if they're ok... or...

Q: yes... it's close to you...

R= yes... rather than looking just through the list of... yes

Q: Do you consider that all the resources offered by the tool, messages, room's layout, image, sound, configurations, are useful to do monitoring?

R= yes... yes definitely... I think, especially when you're on your own is a good thing to have because... you can be always everywhere... you know... at the same time... so yes... it's definitely a good thing to have... yes...

Q: so in general terms do you think the tool is responding to the aim of being something that can support parents with the monitoring of the child?

R= yes... definitely... I think, especially if you are a single parent... if you are by yourself, it would be brilliant because... if you are two of course you got a second parent rise but if... I think it is well like in the nursery environment, in which it will really good, you know you got a big room or the children outside others inside and you have this it'll be a very good way knowing...

Q: What on situations in which you are using a childminder either in private basis or considering a relative to look after your child? So, could you find support from this tool to record your child's experiences like, for example, when she starts crawling?

R= uh, yes... definitely... on situations on which they are looking after and so you can use it to be sure they have been ok during the day... yes, yes...

Q: I was thinking again about your nursery scenario and I think it could be cool if... for the home...

R= I think it could be quite good because... I mean... nurseries are at school up... where children are after a cuddle... they are in places they shouldn't be... and... you know doing something like burning on the heater... you know... it might be something that at least you know, where, when, or what they have done... it might be quite good...

Q: you told me, you liked this (**Space interface**) more than this (**Events interface**)... and I understood that it is because this is not really representative of what is happening in the room... and is not offering enough information for you to be aware of the room's activity...

R= yes... definitely... the only thing with this one (**space interface**)... the dots... they don't, do they move?

Q: no, they don't... they're always at the same position...

R= ok... so it is whether the green or yellow shows on how close ...they are... ok...

Q: could it be good for you to if...

*R= yes... maybe... it seems to be... because here you see the child and, for example, you can see how far they are (**pointing to the media interface**)... maybe it (**space interface**) could have something similar... don't know if that's possible but... if you can see where exactly they are in the room or close to the thing... and then this can be just as good... because you don't have to sort out the thing... what can I see on here... this would be a quick look of the... I mean the colours are still good... but if you actually could see the relative position....*

Q: so you want to have a more real impression of what is the distance between your child and the artefact... am I right?

*R= but as I suppose if you got this (**pointing to the child's position within the media interface**) maybe isn't necessary to have that here (**Space interface**) because you can see from here (**Media interface**) where they are... however, it could help at some point...*

Q: Let see, using a 1 to 5 scale, being 5 highly liked, what is your score, for each of these two interfaces?

*R= Well, I'd say... this would be a 4 (**Space interface**), and for this a 3 (**Events interface**)...*

*R= but then... what I do like from that one (**Events**) is that you can select here and then upload that one (**Media**) ...*

Q: if you're doing something... cooking, cleaning or bedding for example, could you have the chance to look at the device?

R= yes... it's quite small so you can have it in any pocket... other thing is that she is too small so she is all the time with me... but yes when she grow a little, you know the child here the child there... then we can play on it (pointing somewhere within the space interface)... I think yes...

Q: Is the sound helping with the monitoring task?

R= yes... I think, well 'cause I can't remember the sound... does it change? It changes when it is closer... yes... that's was good... because it can make you hear I think... you know... to where the child is close...

*R= whether it may drive you mad, thought, having it all the time... I don't know... as suppose it would be the same like this (**Events interface**) if it hadn't... maybe if you want to tap and send it off but if it comes when certainly the child is really close so that can override little.. it may be useful I suppose... if you don't want to have it all the time...*

Q: let see... so you maybe want to monitor general activity without having sound... but sound when alerts and warnings are present?

R= yes... when there is warning activity then having warning sound... because maybe I don't want to hear the beeps at all the time when you're doing things... but select... you know... when there is something wrong or very dangerous... so you know that before the alert there're safe but when getting close you don't know where they're going in... so you want to make sure that they're ok...

Q: Did you realize any difference with the sounds for GA, Alert, Warning...

R= yes... the alert sound is a little higher, isn't it?

Q: do you think that under situations on which you are doing your housework the identification of the different activity-related sounds is possible?

R= yes... I think yes... 'cause it is like an emergency sound, doesn't it? When it is little higher...

Q: Sounds are quite different or too similar...

R= no... yes... definitely

Q: Do you think that the media interface can be taken out of the tool? Does it matter?

R= it does... that's good... I really liked that one **(pointing to the media interface)**

Q: you won't buy the tool if, for example, the media is not there?

R= yes... I think that one would probably sell it... to people... because they can... it's more real looking at their own doings and things... rather than just a sort of text and images... but a real image from the media interface... personally...

Q: Would you consider this tool as a communication channel between your child and you?

R= not... I want not communication... I think more monitoring... as I suppose it's especially for the child... rather than... because you can't each talk and even if...

Q: What if the scenario is that you are upstairs and the child downstairs, then you received an alert, you watch the room's image but at the same time you can use the PDA's microphone to tell the child "move out there" or "move away from there"...

R= oh, I see... but I don't know... I'm not even sure if the child I suppose... will move out of there, but I don't think I could use it on that way... you know... it is somehow impersonal...

Q: Does the room layout, used at the background of the room-view interface, help you with the spatial identification of activity?

R= yes... and assuming I could have my own lounge layout... when you are getting your own setup, I think yes...

Q: Does it represent a problem for you the identification of the spatial location of the room's stuff when you are walking in different directions?

R= not... because it is supposed that you know the setup for the things in your room... yes... I'll be fine...

Q: Do you think there are some intrusive aspects with the system's collaboration?

Think about doing some household work again, which of the services that you have seen or experienced might interrupt you most? Interrupting you all the time, calling for attention...

R= uh, not because I think... if you wanted you can... the thing is good here is that you can switch off general activity and you can just have it as alerts... you don't... on the way you have the on-demand... so if you don't want you tap it on... if you don't have activity if you feel you're somewhere there you know... nearby you can tap it on... and use it... or you can just leave it on the on-demand... for your own... you can check it...

Q: so, do you consider that there are some available mechanisms to...

R= yes, yes... because you won't probably want to use it all the time, so... if you are nearby or actually with the beds... I f you don't want it you can tap it on...

Q: and these two parameters **(asking about sensitivity and threshold)** are ease to use? Ease of understand?

R= yes... this is the distance, isn't it? And I got a bit confused with this one, what sensitivity does?

Q: this is for the sensors, at sensor level... so you can instruct the sensor to... just restricting the threshold for each sensor...

R= so sensitive... of course... Yes...

Q Using the scale 1 to 5, where 5 is highly demanding, would you mind tell me what could be the score for each of the available services (pointing to the aware levels: general, alert, warning)?

R= just... what was the difference between alert and warnings... 'cause I can't remember...

Q: it is about the distance....

R= oh, yes... oh, there's a warning when it is running very close... and then the alert is in the yellow area... but, goes it red when there is a warning?

Q: yes... if you haven't gotten any it might be because this child had scarce close activity to the artefacts...

*R= ok... yes... that makes sense... I think that's a good thing... I didn't realize if it came on... then, to that I'll give it 5 **(warning)** ad 4 **(alert)**... and then, for general activity... I'll probably for general activity 2, because I don't know how much I really need to know that but I think is something I'll probably use far than alerts or warnings that shows you... I'll probably use it not too much...*

Q: Do you consider that the aware levels can be taken out from the tool?

R= uh, the general activity... yes...

Q: no, the three levels...

R= uh, no, I don't think so... I'll definitely keep them... because I think... especially alerts and warnings are the ones I could be interested in...

Q: Well, ok... you told me something about the availability of the room's picture is something very useful... so I would like to know if for you the identification of the aware areas with the room's image was ease...

*R= no, yes... that's true actually... that's why I suppose that's why this could be good **(simulating the movement of dots within the space interface)**... because here **(the space interface)** you would see the colours... so I suspect you would really see... rather than with this **(media interface)** it wouldn't be necessary to look the thing what are they touching... or too close... but here **(referring to the static dots within the space interface)**, when the thing went red you don't know if they're in danger or... something... because I think, it is the selection **(pointing to the aware levels within the profile interface)** that makes the colour changes, isn't it? So... yes, that's really crucial...*

Q: Is there something that can make you change the way you look after your child?

R= I think it could be difficult to know, because... I have ever thought of monitoring ways... and I'll never leave her on her own... that much...

Q: not at this age...

R= yes... not at this age but... I guess that when she gets older I'll probably bring her with things to play to keep her out of the kitchen and then if moving around... and then on that way it could be good... especially in a big house... because if you are upstairs and they're playing downstairs and they are somewhere playing whatsoever...

Q: yes... accidents happens in seconds

R= and yes... you can't always be with them constantly... and yes... on that way yes... would be good... definitely...

Q: Do you think you would trust a system like this?

R= yes... I would...

Q: Would you modify or change the way you do childcare and housework if you have this tool?

R= yes... yes, definitely...

Q: What could happen if you realize that the system starts misbehaving, throwing false messages/alarms and so on... will you stop using it?

*R= yes, yes, probably... because... so, if you cannot trust it so much if it made mistakes saying things she didn't do... I think you would trust them **(this kind of systems)** even more if they'd prevented themselves... prevented themselves of the fire and this hadn't warned you...*

Let's say it gives a word saying there is a danger, you went dumped but they are ok... it would be so bad...

Q: In general, is there something from the tool that you would like to improve?

*R= what I would like to see here **(Events interface)** are distances... so, say... maybe the way you got here **(Space interface)** with the colours... so I just don't know how relevant it is or whether you need that... because you can see that on **(pointing to a particular event in the event's interface)** here... if you know as it say is the heater and you see a code red... so you know it is a warning for too close...*

*Whereas here it gives you the levels like this does **(pointing within the space interface)** or you can request the picture... but apart of that I think it is good...*

Q: Is there something that you would like to have within the PChCT?

R= I said something before about the spots moving... but actually if you got red, green and yellow then you know anyway how close is it... so I don't know how far it needs to be done... so...

Q=ok... but thinking now about what can be added?

R= uh, I don't think so... I think for me that's ok the monitoring... you have different sounds... maybe the switching off the general sound and just have the sound that comes up when there is an alert or warning

CHILD RB (2.4y)

Child's age: 28 months

Q: What are your feelings after using the tool?

R= fine, everything was easy

Q: but, for example, carrying on the device

R= about carrying the device? Well... perhaps the only issue is when you are walking and pressing the tool buttons... but, I think... there is not need to be worried that much as you can stop... and then you can make use of the tool.

Q: Was there something that you found particularly interesting?

R = yes... that's very good... that's something new for me... I have ever seen anything like this

Q: Can you please tell me which was or were these things?

R= I think it is really good having a tool from which you can retrieve the image...

Q = and....

R= well... yes... with different volume levels to inform you when the child is getting closer to the artefact

Q: Was there some did you like most?

*R= the most... I think it's the room's space interface (**space interface**)... the one on which... there you can observe how the point is moving... so, if you want the image the only thing you need to do is to touch it and that's it...*

R= actually... the other is interesting too because it tells you where each place correspond to, close to the TV, or the heather, that is...

Q: you meant the messages,

Yes... yes... for the messages you only need to request the image and you can immediately see where the child is

Q: Is there something, from using the tool, you liked less? Something that, perhaps was less pleasant or attractive?

R= less?

Q: yes, for example, you said that the space interface is something you like the most, but is there something less attractive?

R= what is less attractive?

Q: the space interface was the thing that called your attention, because you argue the interaction with it is ease

R= but let me tell you that the other is ease too... I think both are fine

Q: what about configuring...

R= um... I'd say... there are not many things I could talk about...

Q: and if, we were in the position of...

R= taking out something?

Q= maybe...

*R= then I would remove the messages (**events interface**)*

Q: Using a 1 to 5 scale, being 5 highly liked, what is your score for each of the available interfaces?

R=well... this **(space interface)** 5... this is the one I liked most... and this **(events interface)**... because you need to search and select messages and then click on the show button, I'll give it 3... and this is really good **(profile interface)**... because it allows you to select what information you need for monitoring... so 5...

Q: and for the media interface?

R= yes... yes... that one is 5 too... though that interface is available from the other two

Q: ok... now if the numbers can't be repeated, what are your scores?

R= Well... if I need to... I think, if everything here is done **(profile interface)**... I mean, it's not really difficult but... if everything has been setup here... though... here you have the options to control what you want for everything and...

Q: ok... but in general what your scores are...

R= well... let see... I'll give it 5 **(space interface)**, this 4 **(media interface)**, that one 3 **(profile interface)** and 2 **(events interface)**... because that one **(media)** does not depend on any of these **(space or events)**... am I right?

Q: and your preference is based on...

R= yes... because this one is ease... because you have this **(pointing to the space interface)** and... clicking twice here you have the image immediately... R= the other is easy too, the only thing is, that you need to read... and I'm not lazy but... you need to look for the message that you want... and then select it again... and then to press the show button... it is easier with the other... double click and that's it... I mean it is quickest than easiest, you know.

Q: Which of the two interfaces you would prefer to use?

R=this **(pointing to space interface)**

Q: Do you consider that the information offered by system is useful? That is, does it meet the aim of being a tool that helps with the monitoring of the child's activities?

R= yes...

Q: yes...

R= monitoring means observing the child by...

Q= let say, the information you are receiving from the child's activities

R= yes... of course... it is interesting

Q= and in your parent's position it helps you to...

R= yes, for example, you said in the introduction that it is possible to record this information **(referring to activity in both interfaces, space and events)**, so that's really good... because there are some things... in my case with my daughter, for example, how she got the scratch on her face... well that's not really bad, just a scratch... but what about the lump on her head? How did she get it? Then for this situation you can go and look there **(referring to the digital album service)** and... I'm sure you will find an answer... you don't need to rely on questioning the child about what happened, because what you usually got is a "no... nothing" answer... do you know what I mean... on these situations really yes... well for many other things maybe... not only...

R= oh, yes... let see, I would like to record everything not only aware activity... because, for example, when you leave the children alone and later on you look for something... sometimes you struggle to find what are you looking for... or... with the tool you can see, for example, the girls hiding or using something when playing such as the scissors...

Q: is it something has happened to you?

*R= of course, I have found the scissors under the pillows... it is true... I'm telling you that because it's something I have experienced... also, sometimes children put something inside the video player... You never realize that the video player is not working because children put something in there... but using this **(digital album)** helps you to see if the child did it...*

Q: And in terms of monitoring the child's activities, do you consider that all the services, mechanisms used to deliver information and the information offered by each of the interfaces are useful?

R= That's depends on where you are installing it, isn't it?

Q: sorry?

*R= because when you install it **(sensing points)**... and configure this **(profile interface)**... and the tool is showing always everything and the child is there but, there is not danger... I think, it might be more interesting if these are placed when there is a potential danger... because it's more useful... what I can see really useful is when the child is getting close to a hazard point and then to be informed...*

Q: but, ok... if we assume that the sensors, computer and everything is working with the monitoring of potentially hazardous areas... so, what you saw, heard, or the interaction you have had with the tool, are all these elements useful, or there are things that you might consider different...

R= no, yes... yes

Q: well, you said it is interesting because it is something new for you but, in terms of monitoring the child...

R= what I have seen yes... everything is useful for me...

Q: what about the aware levels?

R=which one?

Q: those related with the different aware levels such as general activity...

R= do you mean, their sound?

Q: yes... the sound, for example

R= well the sound wasn't really different... or maybe I didn't realize that...

Q: ok

R= I don't know, it is possible to hear little differences, but not for... let see, if you are distracted, if you are not completely aware, I can't identify any difference and realize that... ah that's an alert... definitely... the sound is something I can't distinguish very well.

Q: and what about the image, for example, does it allow you to identify the aware levels?

R= well... I'm not sure... but, no... no really

Q: no?

*R= what I've seen... because I was not... I don't really... that's because in one of the pictures I requested from here (**space interface**), she was doing nothing... so, maybe not really if she is close to the toy box... let see, you are informed that the child is there but you don't know if she is grabbing a toy or grabbing the scissors, for example... so I don't know really*

Q: you said that the image which can be loaded from any of the two interfaces (space and events) is useful and...

R= yes I know, but thinking about that, I don't know... that's true... really, if she grabbed something and I'm not seeing what she is doing... well, yes... I can see the child within the aware zone but.... that's depends on if she is close to the fireplace and playing with her fingers... I'm sure I can see that, or if she is grabbing something from the TV, I think I can see her but considering the toy box I can't...

Q: well... ok... considering only the two main interfaces, room-view and text-based, which of them do you consider is more useful in terms of the information offered to support you with the monitoring of the child's activities?

*R= what I'd say is that both inform you about the child's activity... but the easiest one is this one (**space interface**)... because here you can see the location of the child... and with the other (**events interface**) you need to find out which one is the activity or event... because here you are not informed.*

Q: what do you mean by being informed?

R= it does not tell you, uh... go to the toy box that the child is there, you need to look for the activity, am I right?

Q: let see, you consider that you can't identify the exactly location in which...

R= let's suppose, you received a message, ok... and the message will not turn blue... because it does identify that the child is there, is that true? Or, am I wrong?

Q: um... I'm not sure

*R= lets suppose, if I'm with the messages finding out what's the matter with the child... the child is here ok (**pointing to one of the events**)*

Q: yes, then select...

*R= no... without selecting anything... so the child is close to the central heating... but the text doesn't turn on blue... I need to select it if I want to know more about the event whereas on this (**space interface**) you can realize immediately where the child is and if you want to see the image then touching the display twice and that's it.*

Q: well, maybe you didn't realize that new messages appear at the bottom and they are moving up as new arrives... that is, messages are moving up on this direction... I don't remember if I told you about it... sorry...

*R= ah... ok, but for me the easiest is this one (**space interface**)*

Q: that's your point of view...

R= yes, that's the way I can see it... do not confuse me more

Q: ok, so for you the one that helps informing you about the child's activity is...

*R= yes, this (**space interface**)... this is the one that is ease for me... or maybe I'm a bit lazy...*

Q: Well, using again a 1-to-5 scale which is the score for each of these two interfaces (events and space)

*R= ok, yes... I'm not giving this a 5 (**space interface**) because it's not really clear with... what you can see from the images (**from the media interface**)... so, I'd say 4 (**space interface**) and that one 2 (**events interface**)...*

Q: Which are the weak characteristics from the interface you like less?

R= that I like less?

Q: you said the text-based interface...

R= it is not something I like less but because I need to go for one, yes...

Q: Do you consider that the tool could adequately inform you if there is any potentially risky activity?

R= hazardous? Yes...

Q: if you are upstairs, for example

R= yes, yes...

Q: Does the information, either with messages or room-view, represent what is occurring within the room?

R= uh... as I have said, that's depends... on the situation, don't you think so?

Q: what means depending on the situation?

R= look, something is in my head... if the child is grabbing or touching something hazardous and you can't see that... for example, for the TV you are able to see... and maybe for the central heating... but the I'm not sure if I'll be able to see what's she's grabbing or touching or I don't know... but I'm not sure if it is a hazardous object... the scissors that could be in the toy box but... that could happen, right?

Q: yes, I think it could

R= if maybe she is taking something to her mouth, for example, you can't see that... um, maybe I'm thinking about the worst situation but you told me that...

Q: yes, I think I understand you point about situations on which the camera can only see the back of your child... so it would not be able to have a clear view of the child's activity.

R= yes, that's my point... that's what I can see...

Q: ok, that's right. Well, you said that the sound was...

R= you cannot see if the child is vomiting, too, because there is not a way to realized if the child is vomiting if she is with her back to the camera.

Q: ok, what about the sound? You mentioned that you couldn't realize any difference with the sounds.

R= yes, if I'm just with the attention to the sound, yes... it might be clear, but if you are doing something else because that's the idea, isn't it? You are doing something else and your attention is not completely with the sound... then... I think that if it is a bit louder... even if you are doing anything else and you heard an alarm and you then heard a sound completely different... I think the volume is not the solution what I would change is the sound... yes... that's it.

Q: any other disadvantage?

R= not, the sound and that's it.

Q: but we are not talking about volume...

R= not it is not the volume but the sound... maybe using a... or if you can select it at the same way as sounds can be selected for mobile phones, so when the mobile phone rang you know if it is a message, for example. The same might apply for this (PDA)... you can make an association between the sound and the message.

Q: what were your comments about counting with the image?

R= you can see where the child is...

Q: but is it useful for you?

R= yes, to be honest the image is something I like most

Q: even if it is not clear in all of the situations? Well, consider that this is a print out...

R= well... what I mean is that it might not be clear in extreme situations when, for example, the child is quiet, walking and suddenly she grabbed something and took it to her mouth... However, if the child is touching something, playing with something, for example, with her fingers inside the video player or playing with the central heating controls... then you can see the movements even if the child is with her back to the camera. My child, for example, likes to play with the cooker knobs, and though she can't turn on those yet, she is continuously trying and at some point she will, as it happened once.

Q: Do you consider that the interfaces (events and space) are the same having the media uploading option than without this facility?

R= no, not... they should have the image, of course.

Q: so, does it matter?

R= yes... otherwise I won't buy it.

Q: Consider a situation on which you are doing any housework such as cooking or cleaning, do you think there might be a chance to look for the image?

R= yes, I can be cooking with one hand and with the other requesting the image to see... my little girl

Q: so, do you consider there is not much trouble using it on that situation?

R= yes, I think yes...I imagine myself cooking... then you heard an alarm... and then you thought... uh, I would like to see what she is doing, then you ask for the room's image and you could comfort yourself if, for example, everything seems to be ok.

Q: Does the room layout, used at the background of the room-view interface, help you with the spatial identification of activity? Does it matter if you are pointing in a different direction?

R= I see what you mean. Yes, I think I can identify the room's layout... but if that happens... I think I could upload the room's image... and I can see what's going on within the room... and then, I can see where the child is.

Q: easy to interact with the tool?

R= yes, yes...

Q: if considering "normal" situations of the household attendance do you consider that the tool can be used without any problem?

R= no, I don't think so. But if I can test it for a month... so, I could tell you after that time...

Q: so, do you think this tool will not interrupt your activities?

R= not for me... not in my case... there must be many other cases, but for me conscious of what I have at home... when she is crying the whole day ... that's more annoying...

R= but let me ask you something, this tool, for example, you are talking of using it at home, but I could take it to my workplace, couldn't I? So, I could do some monitoring from there... I think that... this tool is useful not only for children but when you need to make the use of a childminder... I think this might be really good for that... you know parents sometimes leave children alone when they go to work and if they can count with something like this... you know parents are worried with that... you don't leave your children anywhere or with strange people... well I can use it to see if my daughter has woke-up while I'm working.

Q: well... at this stage is not ready for remote monitoring... but it might be possible...

Q: ok, let's continue... if assuming that there are situations on which the tool is interrupting your activities, do you think there are options within the profile's interface that you could configure to reduce interruptions from the tool?

R= yes, yes... of course... with the on-demand service... just when you really want to be reported... or with the use of the digital album, isn't? Yes, I think there are some options...

Q: what about the sensitive and threshold parameters?

R= well, what you have said is true ...

Q: it does help you to...

R= it does bother you less... it reports only what you want... I mean, if you leave the child behaving free or if you want to be reported only when the child is at the limit... or ten centimetres when the child is in movement... it is offering a kind of margin to avoid being interrupted with any movement of the child... for example, the child is in the same position but moving her body from one side to the other...

Q: what about the upper options ("aware artefacts" section)

R= you can select whatever you want, can't you?

R= I believe that each child has different needs, for example, there are children who are very quiet, passive, and you can leave them in a prepared place for them to play... but there are others like mine who all the time are following the parent, and for those cases the tool might not be useful... why I would like a tool like this if my child is always with me?

Q: difficult to understand? Something that has been strange for you...

R= not really, everything has been easy...

Q: the alert, warning and general areas concepts are understandable?

R= do you mean if those are complex? No, they aren't...

Q: Do you think you would trust a system like this?

R= at some point... I could try at least...

Q: I'm thinking of what you've said... it is interesting... that you want to use it first before saying... ok, from now on, I think I could trust in a tool like this...

R= yes, if it is reliable, yes I would be happy... yes, if I can test it for some time, I could say more...

Q: Do you think you would change the way you do childcare and housework if you have this? Could it be altered, modified, or changed?

R= I think I would be less worried... it doesn't mean changing the way of interacting with your child but just less worried... for example, considering my situation... if I'm ironing upstairs... or doing anything else, and I can't hear what Rocio is doing... I'll go downstairs immediately... because I'm pretty sure she is misbehaving... you see... when a child is so quiet you usually suspect something... "what might the child's doings be?" well... something bad... that's for sure... and I use to go downstairs... however, if you can count with this tool you do not need to go downstairs, you don't need to interrupt your doings but just use the tool to realize what she is doing... that's true that sometimes she is doing nothing naughty... just watching the TV... do you know what I mean?

R= ...or the children are in your bedroom and you can see what are they doing... you can monitor them using the tool without going upstairs... so, you can see when everything is fine... yes, I think the tool can be useful...

Q: so at some point...

R= yes... it is not a matter of changing... but you might be less worried... when you are doing both tasks and you don't need to interrupt your activities.

Q: did the system fail to show you the right picture when you requested so?

R= no, it didn't...

Q: when you, for example, requested the image associated to the toy box's activity...

R= no, it was the right picture... though I didn't use it too much but...

Q: yes, ok, but when you used it...

R= yes, it showed the right picture...

Q: does the image correspond to the activity? For example, if the activity was close to the TV... so...

R= what I didn't get once was... oh... no, nothing...

Q: was it ok?

R= yes, I was thinking of events from the TV sensor, but, I remember that it was something I configured, do you remember?

Q: Would you like for the tool to report if the you are at the same room with the child?

R= um.... Yes

Q: yes?

R= because you are not always seeing the child...

Q: have you experienced something like that?

R= Yes, yes... my child uses to play in the small space between the wall and the sofa, and I have struggled finding her... I was with her in the same room... but I don't know. Far as being in the same room is extreme to be honest... but I think I could use it more when I'm in a different room... I think that if I'm in the same room I won't use the tool because I'm keeping an eye on her

Q: In general, again, was there something from the tool that you would like to improve?

R= a better picture, is it possible?

Q: a better picture?

R= not a better picture... but maybe, I'm not sure if it is possible... that instead of a static picture you could have the image for several seconds so you can see part of the child's activities and perhaps what she is trying to do...

Q: let's see, instead of a picture you would like a kind of video?

R= yes, even if it is not for a long time, you know, but some seconds are enough for you to realize what the type of activity the child is doing

Q: is that something to improve the tool?

R= yes, I think so...

Q: ok, you said that a kind of video could improve the tool... but now consider what else can be integrated within the tool...

R= well, I don't know... for me these tool's features are fine...

Q: what we mean here, is that there are some differences when the tool is designed than when the tool is used... thus, sometimes users can help us with some feedback to improve our design...

R= I don't know... the next is maybe a robot that can catch the child when she is in danger...

Q: well, yes it could be... but what about other features to, for example, switch on or off any artefact...

R= oh, yes, that's true... but I think that's... too much for me... it might be good but... in my case I have ever thought of leaving my child alone in the house, even if I have this tool on my hands...

CHILD YM (3.10y)

Child's age: 46 months

Q: What are your overall feelings after using the tool?

R= fine... I think it is almost the same as using a calculator...

Q: anything else? Interesting?

R=yes... I was quite excited seeing the picture of my child... to see that an apparatus can capture your child's picture... the easiest way to have that here...

Q: In general terms which are the things that were more interesting for you?

R= what it's interesting from this tool... maybe... is its capability to detect/identify and prevent accidents in the future... yes, I think...

Q: and in terms of all of the tool's characteristics that you experienced using it... what you heard, read, saw, etc. what are the things that attracted your attention the most? For example, interfaces, mechanisms used to derive information, facilities for interaction...

R= I think... that what it's interesting... is the way the tool allows you to decide what kind of events you want to be informed of... and from all the available events tool allows you to choose the one of your particular interest...

Q: does it mean that what you like most of the tool is that... it gives you freedom to make decisions?

R= well... what I'm interested on, as mother... is on being reported/informed by the tool

Q: ok... let see... using a 1 to 5 scale, being 5 highly liked, what is your score for each of the available interfaces?

*R= I think that one should be 5 (**pointing to the space interface**)... because you can immediately see the hazardous area/point... because if the coloured spot means the child is there and then... if it represents the child and maybe... I don't need to use the other (**referring to the media interface**) if you are seeing the activity here...*

Q: ok... what about the other interfaces?

*R= so... 5 (**space interface**), 5 (**media interface**), 4 (**profile interface**), 3 (**events interface**)... yes, that's fine...*

Q: now... what if scores can not be repeated?

*R= well... in that case... then, I'll give it 5 (**space interface**), this 4 (**media interface**), then 3 (**profile interface**) and 2 (**events interface**)*

Q: Considering the two main interfaces (space and events), could you mention some of the differences between them?

*R= uh... here I can select an event in particular (**events interface**) and here it is shown in general (**space interface**)*

Q: Which of the two interfaces would you prefer to use?

R= space

Q: Do you consider that the information offered by the system is useful? That is, does it meet the aim of being a tool that helps with the monitoring of the child's activities?

R= yes... yes for me...

Q: what are the features that you identify as most useful for monitoring the child's activities?

R= because you can have the image...

Q: anything else...

R= can you please repeat the question? Why I think...

Q: yes, in general, the tool met the aim of being a tool... we propose the tool as a mechanism that could help parents with the monitoring of the child's activities... so with the short experience you had... the interfaces, sound, configuration, informative characteristics...

R= because the only thing you need to do is to press a button and it gives you the picture... and the child's activity... if you are upstairs you cannot see it... the only way is to shout out to your child "what are you doing?"

Q: which are the monitoring characteristics do you so consider of help?

R= it is ease... friendly... I think... the information is clear, and... you can see the image...

Q: what other elements besides the media interface might be useful?

R= wait a minute, is there a special sound for the alert activity? Or will the sound be always the same beep, beep...

Q: they are different... but, there is a section in which we will refer to the sound... so, let's continue if you don't mind...

R= ok...

Q: so you said you like the space interface because...

*R= to be honest, I'm so lazy to... being pressing buttons (laughing)... so, I don't want to spend my time selecting and pressing here and there **(referring to the events interface)**... it is ease selecting something from here **(events interface)** or try to get something... here with a double click you can see the picture and that's it... yes... it seems to be easier here...*

Q: so, considering the two main interfaces space and events and using again the 1 to 5 scale, which your scores are?

*R= uh... I think... I'll give it a 5 **(space interface)** and that one 4 **(events interface)***

Q: Do you consider that this tool might collaborate with you when doing the housework and caring the child at the same time? For instance, when you are doing bedding and your child is "playing" within the living room.

R= at the same time?, yes... I think it is somewhat accessible...

Q: Can you comment about what other benefits could you find from using this tool to support the monitoring of your child?

R= yes... I don't need to stop what I'm doing and... it is possible to see what the child's doings are...

Q: When using the tool... what you see or read, represents what is occurring within the room?

*R= I don't know... what I can see right now, yes... I mean, considering I used it now... yes... there **(pointing to the space interface)** it was reported that the child was close to the TV and the picture showed that too... when it reported that he was close to the toy box the picture showed the same... I saw the picture wasn't always the same... it was different...*

Q: so it gives you the chance to identify what's happening within the room...
R= yes...

Q: are the mechanisms offered to you by the tool of easy understanding?
R= mechanisms?

Q: well, mechanisms are the means used by the tool to inform you about the child's activity
R= uh... yes...

Q: for example, identifying when there is an alert activity... when...
R= yes

Q: Is the sound helping with the monitoring task?
R= yes... *but it could be better if general, alert and warning have a different sound... so you can use the sound to identify the type of the activity*

Q: what could happen if there is not sound... does it matter?
R= yes... *I think... because this is the one most important to me, it is of my interest to have the sound... as I said, if I can hear the sound, it might be enough to identify the kind of activity... the alert area in which the child is playing or if he's close to the warning distance (pointing to the space interface)...*

Q: so, that's considering the space's interface...
R= yes... *here (pointing to the events interface) I don't consider that sound is so important... or maybe yes if I cannot have the other (space interface)... otherwise... I don't care about the events interface...*

Q: Do you consider there is any disadvantage with the sound provided with these interfaces?
R= yes... *the constant beep, beep, beep... it might be annoying... as any repetitive and constant source of sound*

Q: fine, but you said something about the sound being not clear... does it represent for you a disadvantage?
R= yes... *it could be better if you have sound only when the alarm's activity exists... I mean... I'm thinking in something similar to the alarm used for cars... so, only when the alarm level is present the sound is heard...*

Q: what you mean is that you would like sound only under the alert level and not with, for example, general activity... not at all of the time...
R= *one thing, when you hear the continuous beeping is because the child is in movement?*

Q: yes...
R= uh... *so I don't know... because if there is not sound I can't realize when the child is in movement or not...*

Q: sorry?
R= *if there is not sound, I can't know about the child's movements...*

Q: so, your opinion about the importance of having sound is different?
R= yes...

Q: which is your view now?

R= well, that it is important... if the sound represents the child's movements... then it's important... because if the child is too quiet... you can't hear what's about... then... I can't know what the child is doing... if I can't count with the sound to see what's happen

Q: and... is there any disadvantage with the sound?

R= the same... the constant beeping...

Q: so, it is still being something annoying even if at the same time is an advantage counting with it for the monitoring?

R= yes... could it be a smooth sound?

Q: and what about the volume?

R= the same... if you can have some control...

Q: let see, the sound is present and you can control the volume, thus, it stops being a problem?

R= uh... well, I think the sound can be adjusted... I mean it is not the same of having an uncontrolled and constant beeping than having the chance of controlling the sound volume... I think so...

Q: Do you consider the media interface that shows the image associated to the event as useful?

R: of course... then, so... with that you can verify if the system is reporting something that's not true... if the system is lying... or even more if the child is not there...

Q: think about situations on which you cannot see the child when requiring the room's picture. For example, remember that if the child is too close to the TV set he might be out of the camera's view, then, what's your impression?

R= that the tool is not useful...

Q: ok... and when you can see the child?

R= then, it is useful... that it really helps me... having the picture is really important because as I said it could be that the tool is sensing and reporting false activity about the child's activity... maybe the child is not there

Q: so, does it represent a good complement for the interfaces?

R= yes... it does for me...

Q: Consider a situation in which you are doing any household work such as cooking or cleaning, do you think there might be a chance of looking to the image?

*R= uh, not if using this **(events interface)**... I don't think so... I'm not sure if I could look through the messages... but here **(space interface)** yes... even more if I can count with the sound... so immediately... well, I think that if, for example, I'm using this and I'm cooking and then I heard the warning sound... I won't make use of the room's picture... but going to the room where my child is to see what's happen... but if it is the alarm sound then I could request the room's picture to see what the child is doing...*

Q: just to make it clear, if you are doing something like doing the bedding or cooking... could you have time to make the request for the room's picture?

R= yes... not if there is an alert... Why should I need the picture if there is an alert? It is better for me to go downstairs and see what the matter is... but if

normal yes... so, if I'm making the beds and I want to see... uh, now everything is so quiet... why the child is so quiet? I will use it to see...

Q: thus, you first will apply your criteria before deciding if requesting the room's picture or not...

Q: Would you consider this tool as a communication channel between your child and you?

R= not...

Q: If considering the space interface, does the room layout used at the background help you with the identification of the child's activity?

R= yes, because it helps you to identify the room's areas

Q: is it easy for you to identify the room's layout at any direction?

R= yes...

Q: for example, if you are seeing the room in the opposite direction while using the tool is there any problem identifying the room's spatial activity?

R= none....

Q: how easy to use the tool services are?

R= yes... I consider the use of a mobile phone more difficult...

Q: Using a 1 to 5 scale, where 5 is very accessible, what is the score you can give to the user-profile interface in terms of its accessibility to configuring services?

R= I'd say 4

Q: Do you consider that with the use of these configurations (profile interface) you could control the tool's intrusiveness? For intrusive I mean something that you maybe don't want but that is interrupting you, calling your mind...

R= uh... yes... because here I can specify what I want... which areas are more important to me and what I wish from being informed about the activity

Q: and after, configuring/selecting the sub-services from the aware activity service, did you identify any change in the collaboration? There was any change with the collaboration?

R= uh...

Q: Did you realize any change?

R= not really... to be honest I didn't pay too much attention to those

Q: so, you didn't notice any change with, for example, the number of times the system reported activity...

R= not....

*R= wait, I have a question... for example, I can read here... central heating sensor, toy box sensor, etc. for me, this **(referring to the toy box)** does not represent a hazardous area... that the child is playing there with... but if the same place in which the toy box is... is the same place to which the red line is then...*

Q: the red line here **(the print out used to visually indicate the concepts around the general, alert and warning areas)** is just a reference to indicate that the closest distance to any artefact is considered hazardous...

R= even if we are talking about the toy box?

Q: our concept here as a general meaning... for this prototype we included the toy box but it could had been the cooker or any other artefact or appliance... in this case the toy box was considered because...

R= was it the space available?

Q: yes... but, on the other hand, as parent, you might want to know when the child is playing around the toy box because you, for example, might be less worried knowing that the child is playing in a safe room's space...

R= yes... that's why I ask you about that because I consider it is something really important when using the profile interface... when for example, you are configuring the system to be informed only when the activity is within the alert or warning areas

Q: well, even if you didn't identify any difference with the reports from these aware levels, I would like to ask you about their scores

R= well, I'd say... general 5, alert 4 and warning 3... as they appear here

Q: and... which one of these three services fit your needs in terms of the monitoring services?

R= general

Q: Was it easy for you to use the configuration options to establish the three aware levels?

R= Yes...

Q: Are the levels general, alert, warning, useful for monitoring the child's activities?

R= yes... it gives you the chance of selecting what you want being reported...

Q: sorry?

R= that it allows you to select what type of activity you want to be shown... the activity you want from the tool... if all from the general activity or only the ones that are close to the artefacts...

Q: and these sub-services are ease to identify in any of the interfaces?

R= yes...

Q: how you can identify those when using the event's interface?

R= I could identify that with just reading the text... if the child is close to the heater sensor I know that that one is a warning area...

Q: but considering the three levels...

*R= yes... I link this **(pointing to the "Child close to the Heater Sensor" message)** with a warning... is that your question?*

Q: yes... but... for example, within the space's interface you can see coloured points... but here **(events interface)**, how you can identify them?

R= with the text, the word that identifies each of the artefacts...

Q: ok... but the text is the same for any activity, how you can identify if it is referring to general activity, alert or warning_

R= uh... as I said... for me... well, I don't know...

Q: let see, here, do you have coloured spots (space interface)...

R= but here, there is text... just with reading which artefact is present... here there is a message reporting activity around the CH sensor... and that is different

than when referring to the toy box... if that is not valid, then I don't know how to identify the sub-services in a different way... what about the sound?

Q: sound? You didn't identify the sound when using this interface?

R= yes... but if I'm configuring to alert activity then I can use the sound to identify that what is being reported to the events interface is for alert activity...

Q: did you find any benefit using the sensitivity or the threshold parameters? Did you use any of them?

R= no...

Q: well, and do you think there is any benefits having them?

R= yes...

Q: for example?

R= to know how far or close the child is in relation with each of the aware areas... and to know how close is to... if the child is within the safe area then it is fine... if the child is within this area the tool must not report activity... I know the child is ok... if he moves from that parameter to another...

Q: right, that's in relation to the threshold...

R= yes...

Q: and what about the sensitive parameter?

R= what is the use of the sensitive parameter is? It is...

Q: the sensitive parameter refers to this (I'm using one of the print outs to show what the sensitive parameter is used to)

R= uh, yes, that is what I was talking about... if the child is within this area or if he is here...

Q: the threshold is used to define this line (pointing to the alert boundary), but not the sensitivity

R= ok, that's a shorter distance... isn't it?

Q: sensitivity means how much variation exists from one movement to the next... I mean, for example, the child is 20 cm far from the artefact and the next movement sensed is around 25 cm, if you configured the system for a sensitivity of 10 cm then the system must not report any activity. That is, changes on activity less than 10 cm won't be reported

R= well... in that case I found this interesting because it might occur that the child is bent over his knees and standing up or twisting his trunk and that's could not represent an aware event... so, sensitivity could help there...

Q: despite that you didn't have the chance of using the other two aware services: on-demand and digital-album, in general the concepts around these services are clear? Do you think it might be useful?

R= um... it could be... well, I think this is not something that might be useful for me... I don't want to store an album with the child's activity... what I really want is to prevent potentially hazardous activity... and if this cannot be committed in that moment... I might not be interested... It could help me in the situation on which the child has had a bad experience... such an accident... and I wasn't with him at that time... so it could help me to identify what happened... why he is bleeding, crying... I could go to the album to know about that...

Q: considering now the on-demand concept... do you find it useful?

R= yes...

Q: what is its utility?

R= *that it offers to you all of the information...*

Q: are we referring to this service (pointing to the on-demand service)?

R= *yes... this... it gives you all the available information regarding to the child's activity, am I right?*

Q: could the system demand too much attention from you? I mean, you are hearing the beeps, you are aware of incoming events and so on...

R= *I don't think so...*

Q: well, I'm thinking in the situation in which you are carrying the tool and you are with one eye on the tool at all the time...

R= *no...*

Q: could it interrupt your activities, for example, interrupting you when doing the household tasks?

R= *no... I think... I can do both things simultaneously...*

Q: Do you think you would trust a system like this?

R= *no...*

Q: why?

R= *first of all, because is something new... and as any new artefact you need to use it... to explore it... you can't adopt it fully from the beginning*

Q: for how long you need to try the tool to... or what could be your criteria to make a decision if the tool is reliable/trustable?

R= *well... a good reference is if other people are using it...*

Q: so the adoption of this type of tool for you depends on what and how many people are using it?

R= *I'd say... it is like any new product in the market... sometime they offer something that doesn't work in the same way it was promoted... you can't be sure if the new product will be useful or not...*

Q: let me re-word my question... if this tool is being sold and is being used...

R= *it might be attractive to buy and try it... for a month perhaps... just to check if it is useful or not...*

Q: Do you think you would modify/change the way you do childcare?

R= *modify?*

Q: I mean... if you could change the way you look after the child, that you...

R= *it could be (laughing)*

Q: yes?

R= *because you see what is happening or what the child's doings are... so you could say... why I should go downstairs if I can see here **(media interface)** that everything is fine... the child is ok... I think... say... it might happen that you are less aware of what your child is doing, learning, exploring and so on...*

Q: is it a position of being less worried about leaving your child alone in a different room?

R= yes... what I think is one of the tool's goals is to be aware when, for example, you are cooking, or doing something else, and it is important for you to know about what your child is doing. The disadvantage could be if you make use of the tool when you are not busy... when, for example, you are chatting... and so you could prefer to go on with your conversation rather than spending time with your child because you can use the tool...

Q: Would you want the system warn you even if you were in the same room?
R= just when I'm in a different room...

Q: how many mistakes did you get when requesting the picture and realizing that the child was not in the point reported?
R= none... the ones I requested for were right presented...

Q: all of them?
R= the 3 or 4 I did... yes...

Q: and if the tool starts working erroneously... say you asked for pictures and realized that the child is not present on the picture, is there a criterion you can use to stop using the tool?
R= yes... I could try the system to verify how reliable it could be... if not, I'll stop using it...

Q: it is possible for you to think about a number of errors, days or something like that you could include in your criterion?
R= it is just about the reliable collaboration when reporting an event and uploading its associated picture... and perhaps in terms of its sensitivity too... verifying if the tool is using it appropriately or not...

Q: In general, again, is there something from the tool that you would like to improve?
R= um... no... everything is fine for me... is of easy use... it offers the picture to verify the activity... that's ok...

Q: layout, colours, buttons, text, messages, configuration...
R= no... everything is fine for me...

Q: Is there something you would like to have within the PChCT?
R= no...

Q: something else you want to add?
R= do I need to carry the PDA all of the time?

Q: yes... do you think there is a different option?
R= I don't know...

Q: uh, sorry... maybe I misunderstood your question...
*R= because if, for example, I'm cooking and I have any pocket to put the PDA in... so, if I put it there **(pointing to the kitchen space on which the microwave and sink are)** it can get wet... this might be an improvement... a display in the kitchen... to present information when you can't have the PDA with you... or if a base or a dock is available for the PDA... I mean, if I'm cooking the tool can be placed there... using its special space in order to undergo with both tasks...*