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Contextual Locations in the Home

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Contextual Locations in the Home" submitted by Kathryn Kylie Elliot in partial fulfillment of the requirements for the degree of Master of Science.

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Abstract

In this thesis, I address the problem of designing technology for communication and coordination information management in the home. First, I use contextual interviews to examine how households currently manage this information. From these interviews, I identify five types of communicative information. I then discuss how these types are created and understood by home inhabitants as a function of *contextual locations* within the home. The choice of location for a piece of information is important to the functioning of the home, and is highly nuanced. Location helps home inhabitants understand *time, ownership* and *awareness*. Finally, I show how this understanding can be applied in design through two case studies in location-based home technology design. This will provide practitioners and designers with a more complete view of information in the home, and a better understanding of how technology embedded within the home can augment communication and coordination of home inhabitants.

Publications

Materials, ideas, and figures from this thesis have appeared previously in the following publications:

Elliot, K. and Greenberg, S.. (2004) **Building Flexible Displays for Awareness and Interaction.** *Video Proceedings and Proceedings Supplement of the UBICOMP 2004 Conference*, (Sept 7-10, Nottingham, England) 6 minute video and 2 page paper. The same paper also appears in UbiComp Workshop on Ubiquitous Display Environments, held at UbiComp 2004.

Elliot, K., Neustaedter, C. and Greenberg, S.. (2005) **Time, Ownership and Awareness: The Value of Contextual Locations in the Home.** In Beigl, M., Intille, S., Rekimoto, J. and Tokuda, H. (Eds) UbiComp 2005: Ubiquitous Computing (Proceedings of the 7th International Conference on Ubiquitous Computing, Sept 11-14, Tokyo, Japan), LNCS 3660, p251-268, Springer.

Elliot, K., Neustaedter, C. and Greenberg, S.. (2006) **Sticky Spots and Flower Pots: Two Case Studies in Location-Based Home Technology Design.** Report 2006-830-23, Department of Computer Science, University of Calgary, Calgary, Alberta, Canada, T2N 1N4. April.

Elliot, K., Neustaedter, C. and Greenberg, S.. (2006) **StickySpots: A Location-Based Message System for the Home.** *In Video Proceedings of the Conference on Computer-Supported Cooperative Work (CSCW 2006)*, (Nov. 4-8, Banff, Canada) 6 minute video and 2 page paper.

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Chapter 1. Introduction

In this thesis, I address the problem of how to design technology to display and manage communication information in the home environment. To ground this problem, I begin this chapter with a brief overview of existing home technology research and motivation for the problems addressed in this thesis. I will then discuss some of the difficulties encountered when designing information displays for the home environment. Next, I will present each of my specific thesis problems and the goals for this work. Finally, I will conclude this chapter with an organizational overview of the entire thesis.

1.1 Background and Motivation

As computers continue to become smaller and less expensive and wireless networks become more reliable and readily available, computing devices will be embedded within our everyday environments [Dourish, 2001b; Edwards, 2001]. This is part of the new genres of ubiquitous and pervasive computing. The original vision for this "everywhere" computing as described by Mark Weiser [Weiser, 1995] focuses on the idea of environments augmented with computing that would be available whenever and wherever desired. This includes personal and shared computing in many different size scales, ranging from systems built into the environment, down through handheld or portable computers, to miniscule wearable devices. These devices would all be connected with each other over a network. In contrast to conventional desktop computers, these computing devices would be designed to fit into our everyday environment. The vision is that the computers would become so invisible that people would *"simply use them unconsciously to accomplish everyday tasks" [Weiser, 1995]*.

One place where such invisible, pervasive technology could be well used is within the home. Ubiquitous computing researchers now suggest that the home can be augmented by

making it more connected to other places, and more aware of its inhabitants [Edwards, 2001; Intille, 2002b; Kidd, 1999]. The idea is that the home, its furnishings and its fixed and moveable artifacts can somehow display information so that people can access it anytime and anywhere. Example information includes the well-being of distant family members, the school and work schedules of the home inhabitants, weather forecasts and recipes, or videos and music. Many benefits are touted for such pervasive information, including increased feelings of connectedness to loved ones, better time management and more entertainment options [Kim, 2004a; Kim, 2004b; Mynatt, 2001].

It is only in recent years, as computers and the Internet become more and more a part of our everyday lives, that the home has really opened up in terms of the development of applications [Venkatesh, 1996]. As well, many of our homes are now computer intensive. These computers are appearing as desktop computers, TV game consoles, home media centres or as embedded chips controlling dishwashers, toasters and other appliances. In spite of this opportunity, the home environment is not well explored as its own unique computational setting; indeed most work has only concerned the "home office" as an extension of the workplace. There are many different challenges present, including new user groups, new tasks, new potential applications, new design opportunities, and a whole new range of problems relating to privacy, interaction, support and display. The home is not the office. It is not likely that household members, which may include young children and the elderly, will interact with technology in the same way as an office worker seated at a desk in a goal oriented work environment. Nor can one expect the technology to look the same – a traditional PC with a graphical user interface, a mouse and a keyboard may not be the right solution in a home environment. It is certainly not the invisible, pervasive solution envisioned by Weiser [1995].

As a domain of study, the home as a whole is too ambitious for a thesis. Thus the particular focus of this research narrows the scope to home-centered communication and coordination information, along with the artefacts used to convey such information between household members and with the outside world. We include within this category any communication item used within the home or taken from the home into the outside world.

Figure 1.1 Examples of Communication and Coordination Information in the Home.

For example, notes, lists, newsletters, schedules, calendars, voice mail, email, snail mail, reminders and instant messages are all pieces of home communication information. Figure 1.1 shows several examples. On the left, we see a family calendar surrounded by sticky note reminders and to-do lists. On the right we see a family bulletin board covered with phone messages, newsletters and schedules from school, work, church and children's activities, mail, birthday cards, a grocery list, and even pamphlets for potential family activities. This information is used to allow families and households to communicate with themselves and with one another, as well as with people in the outside world e.g. an extended family or a carpool group.

The vast majority of households cope with very large quantities of this information on a daily basis, mostly through a variety of tacit mechanisms. While a technical solution is only one of many possible solutions – it could be that a non-technical solution may work (e.g., filing strategies) – there is a technological opportunity and challenge to somehow augment the home by supplying this information for display and interaction through digital forms.

Designers and researchers are even now proposing how we can do this. Potential design solutions that have been explored include a system for displaying reminders upon

entering or exiting the home [Kim, 2004b], a lamp or a picture frame that shows information about a distant family member [Mynatt, 2001; Tollmar, 2002], even family calendars and context aware intercoms [Crabtree, 2003; Nagel, 2001; Neustaedter, 2006]. However, without a great deal of care, inappropriate designs could lead to constant information overload [Intille, 2002], ineffective uses, or methods and technologies that are poor substitutes for their traditional counterparts. Poorly designed technology will not replace or enhance the rich subtle methods households currently use.

What we really need is a deeper understanding of home inhabitants' current practices in how they organize, use and interact with this information. From a computer science perspective, this understanding is a form of requirements analysis needed to inform software design. Previous work in the area will be the focus of the second chapter of this thesis. To foreshadow what is coming, several researchers have already explored various aspects of communication in the home. Hindus et al. [2001] investigated communication in the home and noted that the home itself is a display, that women are the primary household communicators and that people consider their homes to be sanctuaries. Tolmie et al. [2002] observed the lives of several households and found that routines are of great importance – so much so that Tolmie et al. felt they were "the very glue of everyday life". These routines provide context-specific meaning to actions, and give people shared understandings of these meanings. Crabtree et al.'s [2001] ethnographic study of home life determined three types of places household members use for communication and called these Activity Centres, Coordinate Displays and Ecological Habitats. They observed how information often moved within the home, for example from a place where it is used (an Activity Centre) to a place where it is displayed for others (a Coordinate Display) to a storage location (an Ecological Habitat). They describe these three types of places as being locations where ubiquitous computing could be very valuable within the home. Each of these studies provides valuable information for designers of home technologies – for example where in the home to consider first integrating technology, who will use it, and how routines could potentially be used to provide context so that such technologies are appropriate.

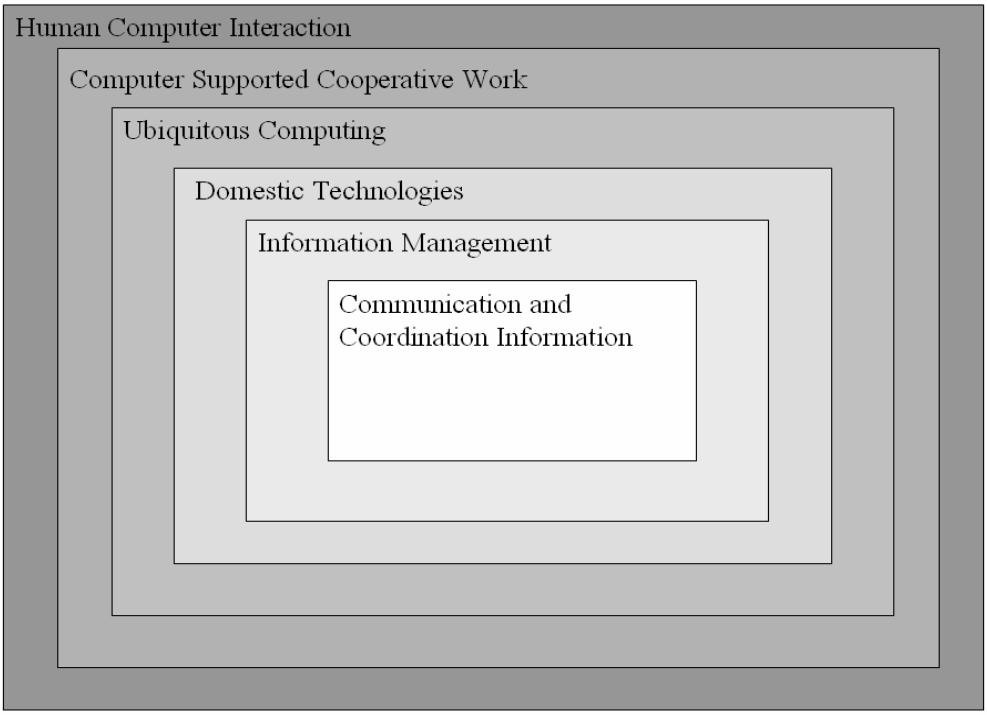

Figure 1.2 Research Context

None of these studies describe the types of information present in the home, or potentially what other information such places or routines might provide to household members. Nor do they provide specific design suggestions for how to display such information. These suggestions are needed by practitioners as they design further technologies for the home. The focus of this thesis is therefore on what kinds of communication information are present in the home, and how best to design information displays for them. Figure 1.2 presents the general context and scope of my research. While it is within the area of Human Computer Interaction, it falls more specifically into the area of Ubiquitous Computing as described above, since we hope for this technology to be integrated invisibly into the home. As I am interested in the home environment, this work is in the sub-area of domestic technologies, specifically the display of communication and coordination information.

For the purposes of this thesis, I will use the word *display* to mean *interactive display* – that is, a way of presenting information so that it can be used and manipulated. I do not, however, intend any limitation on the form of this display or interaction. *Displays* include

not only standard computer displays such as monitors, screens, walls, interactive tables and projectors; but also interfaces we wouldn't normally associate with computers such as physical and tangible displays, aural displays or ambient displays, all of which will be described in more detail in Chapter 2 of this thesis.

1.2 Thesis Problems

The major problem addressed in this thesis is that of how to effectively design technology for the display and management of communication information in the home. I tackle this larger problem by addressing three specific sub-problems.

1. **We do not know what kinds of communication information are present in the home**. While we do know that communication and coordination information is plentiful in each home, we do not know whether there are different types of information, how common each type is, or how people use different kinds of messages. Knowing this is critical if we are to design effective home communication systems that gather appropriate information and display it at the correct moment and in the correct form.
2. **We do not know how household members organize and cope with the communication information in their homes**. Homes contain a vast amount of information. It is unclear what mechanisms people use to know which messages are relevant to them at particular times. We do not know how household members organize personal information or information for other members of their households. We do not know how each member decides what pieces of information they are or are not responsible for, or how this decision making process changes over time. Yet this information is needed if we are to design information displays and interaction metaphors that fit naturally into the home. This understanding and natural fit is vital in the home environment, as people are slower to accept technology in their homes [Venkatesh, 1996] and will be less tolerant of any system that is not easy to use or that does not fit smoothly into their domestic routines.
3. **We do not know how to design natural systems for the display and management of**

communication information in the home. The home is a very different environment from the workplace. While there has been much research into designing information systems for the office, not as much work has been done in the home, where people's needs and desires for technology and goals for information management are less well understood. It is unclear how a system for managing information in the home should be designed in order to provide natural support for this very different type of information management.

1.3 Thesis Goals

This thesis presents the results of three main research goals, each which contributes to solving the three problems above:

1. **I will investigate the types of communication information currently present in the home.** I will perform an exploratory study, consisting of contextual interviews and observations in the home. The outcome will be a classification and comparative discussion of the types of communication information present in the home. The implication to practitioners will be suggestions for how this information types could be used in home technology designs.
2. **I will investigate the methods currently used by household members to organize communication information within their homes.** As part of the study described in Goal 1, I will also observe how people use, manage, and organize the communication information present in their homes. The outcome will be a discussion and classification of how people deal with this information. As with Goal 1, the implications to designers will be suggestions for the design of technology to support these activities within the home.
3. **I will design prototype home information systems where people can present and interact with information in the home environment.** Using the suggestions defined in Goals 1 and 2, I will design, implement and critique two information systems for the home environment. These will serve as case studies of how the implications from Goals

1 and 2 can be used to design for the display and management of communication information in the home.

1.4 Organizational Overview

This thesis is divided into seven chapters:

In Chapter 2, I present an overview of the literature in the area. In order to situate this work within the broader context, I begin with previous work in ubiquitous and tangible computing. Next, I present relevant literature related to smart homes and home technology examples. I will also look at previous approaches to studying the home and see how their results influence this work.

In Chapter 3, I describe the methodology used in the exploratory study and present and describe the **types of communication information** found in the home and the different information media. This work goes towards solving Goal 1.

In Chapter 4, I present the second part of the results from the study. These results relate to the role of **contextual locations** in how household members organize and deal with communication information. Next, I complete Goals 1 and 2 by discussing several general design implications provided by these contextual locations and by the information types and media described in the previous chapter.

In Chapter 5, I describe **the StickySpots location-based messaging system,** the first of two home information systems I designed and implemented as examples or case studies of how the implications from Goals 1 and 2 might be put into practice.

In Chapter 6, I describe **FlowerPots: a location-dependant information display –** my second design case study. This display extends a previous design to make use of the implications from Goals 1 and 2. The two case studies, as described here and in Chapter 5, complete Goal 3.

In Chapter 7, I specify my research contributions, and describe the next steps for this work.

Chapter 2. Technology in the Home

The concept of the home of the future – filled with technology to make our lives easier, to connect us to family and friends, to entertain and to educate us – has captivated both designers and journalists for years. The idea of a "smart" home that could turn the heat up on cold winter mornings, turn on the coffee maker at just the right time, or show you a weather and traffic report on the bathroom mirror is certainly attractive. However, the reality is that this technology, if it is to be truly liveable, is still in the future. There are many facets of home life that must be better understood, and many challenges that must be met, before we can move from technically possible to socially acceptable.

In this chapter I present a brief literature review of technology in the home. My goal is to frame and motivate my work within both the existing body of research and the challenges of designing for the home. I will first discuss how technology is moving away from the desktop computer through Ubiquitous and Tangible Computing. Second, I will talk about Smart Homes – these "homes of the future" that use technology to enhance the lives of their inhabitants. I will then present some examples of existing home technology systems and designs. Third, I will discuss some key findings of existing domestic studies. I close by using this knowledge to frame my own research.

2.1 Moving off the Desktop

> *"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" [Weiser, 1991].*

There are currently several areas of Human-Computer Interaction (HCI) research that are deliberately moving away from the standard personal computer with mouse and keyboard

interface. Ubiquitous and Pervasive Computing, along with Tangible Computing and Physical User Interfaces are changing the way computers fit into our world.

2.1.1 Ubiquitous Computing

The idea of "everywhere" computing, also known as Ubiquitous or Pervasive Computing, was first presented by Mark Weiser in 1991 [Weiser, 1991]. This is the idea that computers, like motors or writing, could eventually vanish into the background, to be *"invisible in use" [Weiser, 1991]*. People could then use computing technology without thinking about it, the way we read signs, product wrappers, and billboards; or how we scribble quick notes. Weiser discusses how, with current technology, users need to know so much about the technology itself that they are like early scribes who *"had to know as much about making ink or baking clay as they did about writing" [Weiser, 1991]*.

Ubicomp, as it is most commonly called, includes different sizes and shapes of computers and displays, both much bigger than the standard desktop, and much smaller. Some may be instantly recognisable as computers, while others will simply be an integrated part of the environment. As one example of Ubicomp's opportunities, consider the standard computer display. Wall displays, tables, handheld devices, specialised information appliances of all shapes, and tiny displays integrated into a wide variety of products are just examples of how computing becomes "everywhere". The full vision includes having information, applications and interaction move seamlessly from one display or device to another, depending on what the users wanted to do. The idea is to enable people to *"use [technology] unconsciously to accomplish everyday tasks" [Weiser, 1991]* – this seamless interaction is where the real power of the concept emerges.

An example of an implemented ubiquitous environment is the i-LAND room [Streitz, 1999] shown in Figure 2.1. The room consists of a large touch sensitive display that covers an entire wall, an interactive table that several people can work on together, and two CommChairs – chairs with a built in tablet style computer. All of these are interconnected: the chair's display can be used to annotate something on the wall or can save something created on the table for later use. Digital files are moved from one place to another using

Figure 2.1 The i-LAND room: Collaboration on a wall display, and remote annotation from a CommChair to the wall [Reproduced from Figures 2 and 5, in Streitz, 1999, page 124].

any uniquely identifiable physical object – a block of wood, a ring, a book, etc. – that is placed on a weight-sensitive platform called a Bridge, which recognises the object and brings up associated files. This type of office environment is only the beginning. Future Ubicomp environments could contain many more computing devices in possibly unrecognisable forms – the standard computer display is only one example. Ubiquitous Computing goes beyond this to include interactive devices of all types, with or without conventional displays or modes of interaction.

Ubicomp also includes sensing, as this is how technology will "know" about users, their context and the surrounding environment. This could include cameras, active badges, RFID tags and readers, along with a wide variety of environmental sensors such as light, weight, motion, heat etc. By knowing about the world, Ubicomp technology can provide invisible support and more natural interaction.

2.1.2 Tangible Computing

Related to Ubiquitous Computing, and the second way in which HCI is moving away from the mouse and keyboard is the idea of Tangible or Physical User Interfaces (TUIs or PUIs).

The goal here is to bring computing, information and interaction off the screen and into our real world in a way where we could interact with digital information in the same way we interact with the physical world. That is, to *"change the world itself into an interface." [Ishii 1997]*. This includes making surfaces such as tables and walls, or even ceilings, doors and windows, into interactive displays. It also includes novel interfaces where the state of a physical object represents associated digital information, and manipulating this object controls the data. Tangible Computing, especially as presented by Ishii et al. [Ishii, 1997] has three major goals, which I will describe in turn.

The first goal is to make ordinary surfaces in the architectural space into interactive interfaces. In practice, this has primarily consisted of interactive tables and walls, but could also include furniture, the ceiling and floor, or even windows and doors. This could involve using projectors, digitally controlled lights, touch sensitive surfaces, or tracking cameras to display information and allow people to interact with it.

Secondly, Tangible Computing seeks to use ordinary physical objects, such as clocks, books or blocks as ways to display and manipulate digital information, especially information that pertains to them. For instance, in Ishii's ambientROOM, seen in Figure 2.2, a clock with exposed hands can be physically manipulated to review past and even future states of the room's various displays. A second example from the same project is pair of small bottles that when uncorked, "release" information into the space – in the example, this information is traffic noise representing network load [Ishii, 1997; Wisneski, 1998]. These physical manipulations are more natural than clicking or

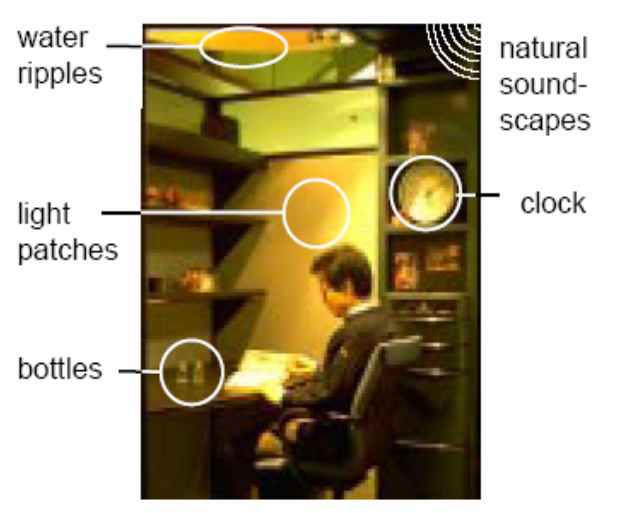

Figure 2.2 The ambientROOM [Reproduced from Figure 4 in Wisneski, 1998, page 26].

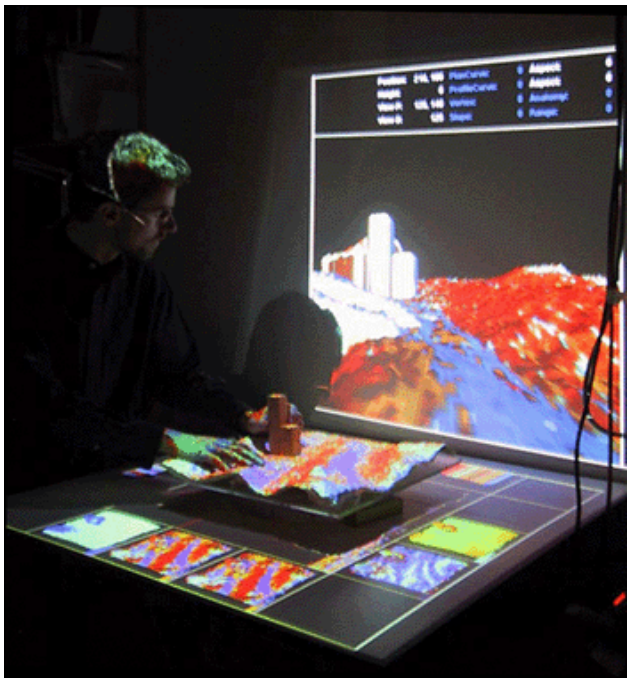

Figure 2.3 A user manipulating a modelled landscape directly with the tangible Illuminating Clay system [Reproduced from Figure 3 in Piper, 2002b, page 3].

starting a program on a monitor, and are easy for people to understand. Another way these interfaces can be used is as a way to physically manipulate digital information, as in the Illuminating Clay system by Piper et al. [Piper, 2002a], where users manipulate the topography of a clay landscape model with their fingers, and the changes are sensed and fed into the digital model in real time, as shown in Figure 2.3. The digital model then projects areas of concern (e.g., potential landslides caused by the changes) back onto the physical model, so users can easily see connections and make alterations.

The final goal of tangible computing is to employ the periphery of our attention to display slowly changing information. These are called Ambient Displays. They enable users to be aware of information in a natural background way, by displaying it off the monitor, and out of the centre of the user's attention. Mark Weiser, the founder of Ubicomp, called these displays "Calm Technology" [Weiser, 1995] as they move back and forth naturally from the centre to the periphery of our attention as needed, rather than constantly demanding our focus. He

Figure 2.4 The Dangling String: an ambient display of network activity [Reproduced from Figure 1 in Weiser, 1995].

presented an example created by an artist that consisted of a simple piece of string dangling from the ceiling in the corner of a hallway, as shown in Figure 2.4. The string was attached to a small motor that was activated by bits passing through a nearby Ethernet cable. When the network was very busy the string would whir rapidly and the motor would be audible. A quiet network would result in a string that moves gently and more quietly. People in nearby offices were therefore aware of the status of the network, including any interesting changes, without having to actively check or test it [Weiser, 1995]. Many other diverse examples have been built, using such unconventional media as air bubbles in water [Heiner, 1999], Mondrian-like artistic patterns on wall displays [Hallnäs, 2001], dynamic music [Tran, 2000] and ripples of light on the ceiling [Ishii, 1998]. These ambient displays are often rather abstract and artistic, making them an aesthetically pleasing part of the physical environment.

2.2 Embodied Interaction

The connection between social computing (such as the kinds of home technologies discussed in upcoming sections) and Tangible and Ubiquitous Computing is how these all rely on our own familiarity with the world – be it our social worlds and how we interact with each other, or our physical world and how we interact with objects and our environment. Dourish [2001] calls this connection embodiment.

> *"Embodiment is the common way in which we encounter physical and social reality in the everyday world. Embodied phenomena are ones we encounter directly. (...) For the proponents of tangible and social computing, the key to their effectiveness is the facet that we, and our actions, are embodied elements of the everyday world" [Dourish, 2001b].*

Embodied interaction [Dourish, 2001b] is an approach that takes this idea that we inhabit and directly understand social and physical interactions in the real world, and seeks to apply it to the design of interactive systems. So technology that uses embodied interaction would seek to be *"...grounded in mundane, everyday experience" [Dourish, 2001b]*. Technology that supports embodied interaction is thus *"...coupled to the world..."*

[Dourish, 2001b] so that we not only act on it as an abstract object, but we act through it on our world [Dourish, 2001b]. The main idea here is that technology should fit into the real social and physical practices of people.

In the home, social practices are complex and ill-articulated, as discussed at the end of this chapter. These social practices are critical to how the home functions and how the home inhabitants interact with each other, especially in the case of a family. In addition, people have different motivations for adopting technology in the home – for instance, there are different user groups present (including the elderly and the disabled) and the aesthetics of new technology must meet different standards in order to fit into the home environment. This idea of embodied interaction can thus be seen to be especially valuable in the domestic environment as it seeks to disappear not only into the environment as in Ubiquitous Computing; and not only into our understanding of the physical world as in Tangible Computing; but also into the social experiences of the inhabitants, so that it is *"invisible in use" [Weiser, 1991; Dourish, 2001b]*.

2.3 Context-Aware Computing

One way in which computers could become more invisible is to allow them to know more about their users and their surroundings. Context, the *"...physical and social situation in which computational devices are embedded" [Moran, 2001],* could allow these devices to provide support in an intelligent, natural way. For example, if your cell phone could know when you were in a meeting, concert or other quiet place it could automatically vibrate or send callers to voice mail instead of ringing [Moran, 2001]. As a second simple example, a computer display could automatically adjust its brightness to the room's light level so as to not be too bright at night, or unreadable in the daytime. This is called Context-Aware Computing, and is part of the same overall idea as Ubiquitous and Tangible Computing and Embodied Interaction. The goal is to make computers more intelligent about our social and physical worlds, in order to allow for more natural, more unobtrusive interactions with them.

Context is *"information that can be used to characterize the situation of an entity" [Dey, 2000]*. Dey and Abowd [Dey, 2000] further specify this into four categories: location, activity, identity and time – that is: where someone or something is, what they are doing, who they are and what time or date it is. These pieces of "primary context" can be used by a designer or a system to acquire more detailed information, or "secondary context" – for example, by using a user's identity to acquire their email address from a directory [Dey, 2000]. This context is gathered through the use of sensors and cameras. Sensors could include motion, light, weight, touch or biometrics. Cameras, used along with computer vision techniques, could identify people or objects and track them, along with many other uses.

"A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task" [Dey, 2000]. Context-aware systems use context information, both primary and secondary, to know about their users and their environment in order to deliver relevant and useful services and information. For example, the GUIDE system is a context-aware tour guide developed to assist visitors to Lancaster [Cheverst, 2000]. The system, which runs on handheld devices, senses wireless location beacons in order to determine where in the city the user currently is. It can then provide information to users related to their location, such as the building's history or nearby restaurants [Cheverst, 2000]. Another example, again using primarily location information is the Xerox ParcTab system [Schilit, 1993]. In this system, each user wears a small portable device that knows where it is, and which other devices are nearby. It can then provide location-sensitive support such as showing information about the room it has entered – such as a library catalog when the library is entered. The tabs can also be used as a remote control for the nearest device, or could even locate desired devices, such as the nearest printer or projector [Schilit, 1993]. The system could also record who else was present at a meeting, and provide their contact information afterwards.

There are many challenges in Context-Aware Computing, not the least of which is how to gather the needed context [Moran, 2001]. People are capable of recognising a huge number of things about their environment and the people and devices within it that are very

difficult for computers, even with sensors and cameras, to recognise. A lot of Context-Aware Computing work focuses on how to gather contextual information. Privacy is obviously another huge concern, as the more information you gather about people, especially when you are gathering it indirectly, the more important it is to protect that information. I will not go into more detail here, as this is not the focus of my work. However, it is a big part of current visions of the future home, as will be discussed in the following section.

2.4 The Home of the Future

The overriding vision of these movements is that computing needs to extend from the desktop into the real world so that it becomes part of people's natural patterns and practices. One environment where this shift has great potential is in the home, both in terms of the home itself, and the technology we have within it.

2.4.1 Smart Homes

The context-aware home, also called the "smart" home, is the idea that your home will contain cameras, sensors, actuators, wireless networks and a wide variety of intelligent devices that will work together to know about you, to control your environment, and to help you. As discussed in the previous section, this fits very naturally into UbiComp, as the goal is to *"offer an unobtrusive and appealing environment embedded with pervasive devices that help its occupants to achieve their tasks at hand" [Meyer, 2003]*.

Many scenarios for context-aware homes have been predicted by scientists and journalists [Meyer, 2003]. Some of the more recurring include:

- lights, music and even pictures that adjust to the preferences of the room's current occupants;
- homes that support elderly people living alone, extending the time they can continue to live independently in their own home, and providing comfort to extended family members;

- family intercom systems that allow people to speak to each other from different rooms, or even different houses as though they are in the same room;
- smart appliances that communicate and provide support – such as a fridge that orders milk when you get low, or a coffee maker that starts itself when your alarm goes off in the morning;
- security and environmental controls that make the home more comfortable, more efficient and more secure.

There are also more humorous (and frightening) versions of the smart home, as in Figure 2.5, where your bathroom scale tells the fridge that you're overweight, so the fridge refuses to let you have another beer [Barry, 2003]. These show us that people's anticipated experiences with technology are not always encouraging, so it is important that the smart home be well thought out and be what people actually want and need.

There are several prototype smart homes currently built. Among these are the Aware Home project at the Georgia Institute of Technology [Kidd, 1999], House_n at MIT [Intille, 2002b] and HomeLab from Phillips Research [de Ruyter, 2003]. While ethical concerns prohibit users from actually living in these homes, they are valuable test beds for ubiquitous home technologies. Each of these projects has a different focus; the three together show the diversity of the research in this area, and the variety of ways it could benefit home inhabitants.

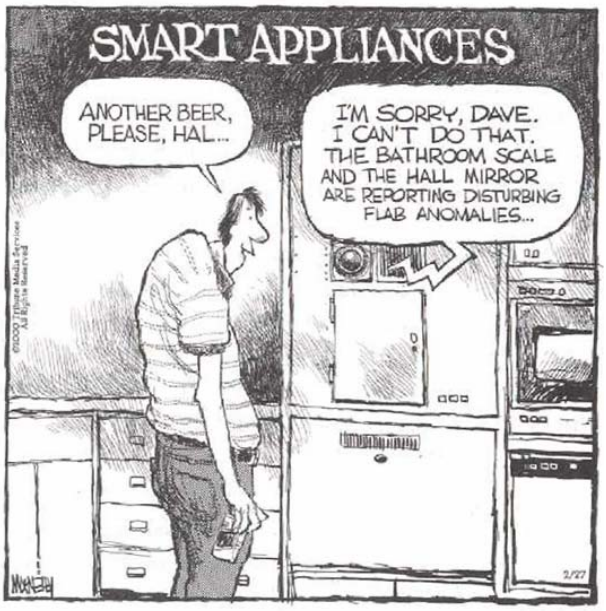

Figure 2.5 The scary side of the smart home [Reproduced from Barry, 2003. Cartoon drawn by Jeff MacNelly].

The Aware Home project is interested in supporting everyday activities, such as finding lost objects,

assisting the elderly, providing memory support, naturally capturing family moments, and keeping in touch with extended family and friends. An example project is Peek-A-Drawer [Siio, 2002]. This is a way for grandchildren to communicate with their grandparents – it connects two homes. There is a chest of drawers in each home. Items are placed in the drawer by the grandchildren and are displayed on an LCD in the grandparents' drawer. Newer iterations of the project allow the grandparents to add voice annotations to the images to be sent back to the grandchildren. This allows children to easily share things with their grandparents, and for grandparents to have a rich connection with their grandchildren beyond phone conversations and rare visits.

House_n is a collaboration between architecture and technology, and is interested in being a "teaching home", that provides people with information to help them make decisions. This home does not take any control away from the inhabitants [Intille, 2002b], but rather uses subtle reminders to, for example, encourage home inhabitants to be more energy conscious. They are using two platforms: a movable projector system that allows information to be displayed on any surface [Pinhanez, 2001] and portable computing systems such as PDAs or mobile phones. The idea is to present information at the right place and time, to provide "point-of-decision" messaging. This project is also looking at how to build a home that lets technology be easily embedded, changed and upgraded – a major challenge in Ubiquitous Computing [Intille, 2002b; Edwards, 2001].

HomeLab, by Phillips Research, is working on a concept they call "Ambient Intelligence" [de Ruyter, 2003]. They are looking to create technology that knows about its inhabitants, and that anticipates and supports their needs. These prototypes are intended to be smart – they require very little interaction from the user. Since Phillips is an electronics company, there is a large focus on improving and developing electronics to eventually be made into commercial applications or appliances. An example project is a system that displays silhouettes of remote people watching the same program overlaid on the program itself, to give a sense of watching together. Other examples include the use of ambient light while watching TV or listening to music; and a remote control that is context-aware – it

knows if it is in a drawer, on a table or in a hand, and modifies how it delivers upcoming show reminders accordingly.

2.4.2 Home Technology

Beyond these large scale context-aware home projects, there are also many other examples of appliances or prototypes designed specifically for use in the home. I am going to discuss five separate examples here, chosen for their diversity, and for how they relate to my own thesis research.

Digital Family Portraits

As discussed in the previous section, one of the major themes in smart home research is providing support for older adults who wish to continue living independently. The Digital Family Portrait [Mynatt, 2001] is an example of this. It is designed to provide peace of mind to the caregivers of these seniors – for instance their adult children. The goal is to provide awareness for these caregivers as to the senior's activity level, environment, relationships, daily events, general well-being and long-term health.

The Digital Family Portrait is intended to be displayed on a mantle or bookcase, or mounted on the wall like a typical picture of a loved one. However, the frame of the portrait changes daily to reflect the status of the one it portrays. This allows the caregivers to keep an eye out for their loved ones, much as they would if they lived in the same house, or next door.

Icons are placed in a band along the edge of the frame, as shown in Figure 2.6, where their density, size or colour represents the levels of the various categories, while their placement around the edge represents time. In this way trends can be seen (e.g. poor sleeping, not getting out enough) as well as unusual days (e.g. a day with exceptionally low activity). In the field study, Digital Family Portrait functioned not from sensor data, as that is hard to obtain and calibrate, but from daily interviews with the participants which would result in a ranking assigned to that category by the interviewer. The study, done between a grandmother and her two grandchildren, found that both liked the portrait information, and

Figure 2.6 The Digital Family Portrait, showing changes in activity (left) and health (right) over time, highlighting trends and an unusual day [Reproduced from Figures 4 and 5 in Mynatt, 2001, page 338].

that it would lead to further conversations over the phone. This lightweight emotional awareness was desired and enjoyed.

The Family Portrait is an excellent example of how dynamic, networked digital displays can connect people with a pre-existing relationship and provide emotional connections. It is also a good example of how contextual information could be used to support this kind of awareness in a natural way.

6th Sense Presence Lamp

Another example of a home technology designed to connect people at a distance is the 6th sense presence lamp [Tollmar, 2002]. This is a pair of small physical lamps like the prototype shown in Figure 2.7 which are remotely connected. The lamp measures the amount of movement near it, and when it sees enough movement, it interprets it as presence, and sends a message to illuminate the other lamp in the pair. When no movement is detected, the paired lamp is dimmed. The lamps are used to evenly connect pairs of households, e.g., parents and adult children living away from home for the first time, adult siblings, or aging parents and their children. The lamp is thus an ambient display of the presence of the remote loved ones. A field study of the lamp found that people felt more

connected to their loved ones when they had the lamp, and that it made them think of the ones it represented.

Figure 2.7 A prototype 6th sense presence lamp [Reproduced from Figure 4 in Tollmar, 2002, page 46].

This project is similar to the Digital Family Portrait in that it communicates awareness information and provides an emotional connection. However, it differs in that it provides an equal connection – both households have equal awareness of the other – and in that it is a purely physical object rather than a digital display. A lamp was chosen as it is a common object, and because light naturally indicates presence, i.e., you only turn the lights on when you are at home. In interviewing people about objects in their home prior to designing the lamp, the researchers found that the items that meant the most to people were those with an emotional connection to someone they loved, or a history of some kind; rather than those that served a purely utilitarian purpose. This indicates that physical objects in the home that are digitally connected to loved ones, such as the 6th sense lamp, have great potential to be valuable to household members.

TxtBoard and HomeNote

TxtBoard [O'Hara, 2004] is a system that allows household members to send messages from outside the home, and have them displayed in the home on a special digital message board. TxtBoard is a small screen mounted to the wall or placed on a table that can receive messages sent from any standard mobile phone. It displays these messages along with an image of the sender, caller ID, time and date information. The frame of the message will glow to alert people in the home to a new message. Messages can be browsed, saved and deleted. Replies cannot be sent through the system, but since a phone number is displayed, the sender could be contacted by phone.

The main idea here is to allow for text-to-place messaging. That is, allowing messages to be sent to a place rather than to a specific person. Household members can send a message home for whoever is there to see.

The TxtBoard device was placed in a public, central location in the home that had a lot of traffic. They found that people used the device for calls to action (e.g., asking for a ride from the train station), providing awareness (e.g., where someone is), and general "small talk" (e.g. how someone's test went). While it would be possible for people outside the household to send messages to the board, the study participants did not give out the number, feeling it should be for the household only, as it was broadcasting to all of them.

HomeNote [Sellen, 2006] is a system developed on the TxtBoard platform. Shown in Figure 2.8, it is a pen-sensitive display mounted on a wall or displayed on a counter that receives text messages sent from mobile phones. However, HomeNote adds the ability to create or annotate messages with a stylus, so messages can be created or added to in place, though replies still cannot be sent – the scribbling appears only locally. Through user studies, they found similar uses for HomeNote as for TxtBoard. However, they also found that the addition of local ink messages allowed for some new uses: identity broadcasting, reminders, passing on of other messages (e.g. phone messages) and as an information store (e.g., to note lists or phone numbers). The ability to easily ink and save a message, and the

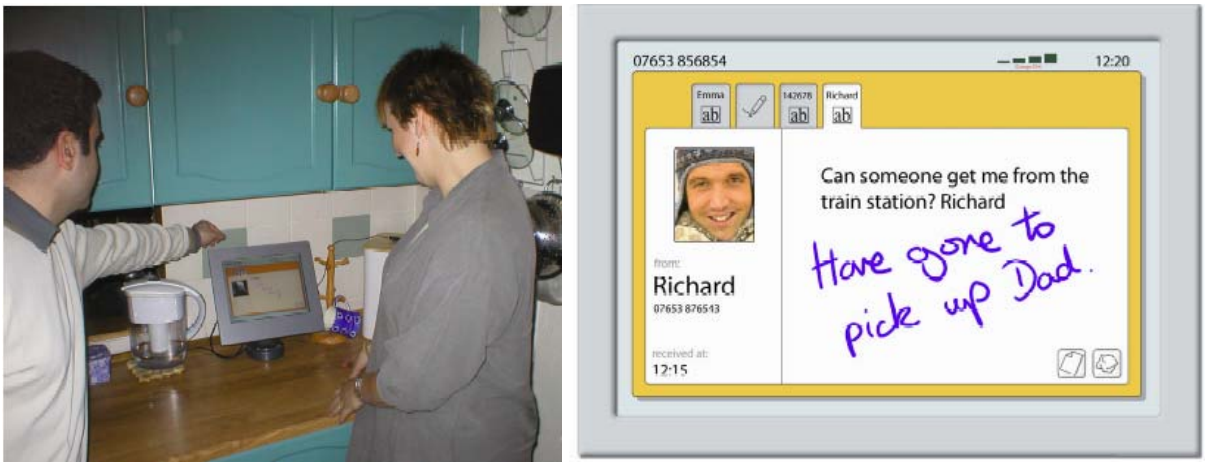

Figure 2.8 The HomeNote messaging system [Reproduced from Figures 2 and 1 in Sellen, 2006 pages 3-4].

fact that it was located where it would be frequently seen by other household members, meant that it was now used for these kinds of information. However, this information, as well as any other messages sent to the device, could not be forwarded, replied to, or displayed in any other place in the home without switching to a different media (e.g., the phone, a paper note etc.)

The location of the device was also very important in terms of its usability, a theme my work will explore in much more detail. The display was made more valuable because it was in a public, high traffic area of the home, meaning that household members sending messages to it may not know *who* will be receiving the message, but they know *where*, and that context has value to them.

Gate Reminder

Gate Reminder [Kim, 2004] is another system that uses a household location and the routines associated with it to effectively display information. Here, a small screen is attached to the wall near the front entranceway of the home. It is used to display reminders needed as people enter or exit. These reminders can be handwritten on the display using a stylus or sent from a mobile phone, as in HomeNote [Sellen, 2006]. The system also uses RFID to detect when users have forgotten a routinely carried object, such as a cell phone or a wallet.

The system uses face recognition through a small camera, and voice recognition through a microphone, in order to determine who is present. It also uses sensors in the door and motion sensors in the foyer to sense if people are entering, exiting, or simply grabbing the mail or the newspaper from the front step.

While the system was not implemented in a real home, only as a prototype in a research lab, it is easy to imagine how it would be helpful. An example of how the system could be useful is explained in Figure 2.9. A friend you are visiting the next day asks you to bring a particular DVD for them. You enter the reminder into the Gate Reminder system. Then when leaving to meet your friend, the system identifies you and displays the reminder, so you don't forget the DVD.

Figure 2.9 A storyboard for the GateReminder system [Reproduced from Figure 1 in Kim, 2004b, page 83].

Again, the placement of this system within the home gives it a big part of its value. The fact that it will be seen as part of the routine of leaving or coming home is very valuable. This theme of location is a large part of my work, and will be discussed further in Chapters 3 and 4.

The Everywhere-Displays Projector

A final example of a home technology system is the Everywhere-Displays Projector [Pinhanez, 2001; Intille, 2003a]. This is a projector combined with a computer-controlled tilting mirror that allows the projected image to be displayed on almost any surface in the room, including the walls, furniture, floor or ceiling. A camera is used to see the image so that it can be adjusted to look flat and square, even when projected on an angled or uneven surface. The camera also makes the system interactive when used with a laser pointer [Intille, 2003a] or, though not yet functional, through finding the user's hand and its shadow, so the projected image could behave like a touch screen.

This system is used, for example, as a language learning tool [Intille, 2003a]. The projector randomly projects the French name for an object onto it (e.g. "chaise" onto a chair). By pointing to the word with a laser pointer, the English translation is shown. A second point plays the pronunciation of the word over the room's audio system. This projector system is very flexible and could be used for a wide variety of information displays, such as accessing computers in public spaces or hazardous environments (e.g. the kitchen, where a normal computer risks getting wet or dirty or a factory where sparks are not allowed) or to bring access to the disabled (e.g., by bringing the display to them) [Pinhanez, 2001]. This is true "ubiquitous computing", where the display can truly be anywhere and everywhere.

2.5 The Home is Not the Office

There are several threads in these projects that connect to my own work. The use of physical devices, ambient displays, dynamic digital displays as well as the use of location will all return in my own designs, described in Chapters 5 and 6. Another common thread in all these projects is that there is tremendous potential for technology in the home, but that it is challenging to implement this technology in real homes, and it is very difficult to anticipate what people will actually use. Most ubiquitous technology research, up until the last five years or so, has focused heavily on the office. The home is a completely different environment, and is not yet well understood.

There are many challenges when it comes to designing and implementing ubiquitous computing technology in the home. Seven major challenges have been identified by Edwards and Grinter [2001]. These include many technical and integration challenges, such as how to integrate ubiquitous computing into existing homes without requiring a great deal of expensive renovation, and the fact that Ubicomp currently does not have the reliability or interoperability that it would need to be commercially viable or even practical in real homes. While these technical challenges are both difficult and important, they are not what I explore in this thesis.

More related to my own work are the two challenges listed by Edwards and Grinter pertaining to the social implications of domestic technology, and how these implications affect design. The first of these challenges is that aware home technology has a wide variety of social implications that must be considered, such as privacy, changing societal expectations brought on by new technology, and other unforeseeable social consequences [Edwards, 2001]. For example, while the washing machine was advertised as a labour-saving device, the ease it brought to cleaning clothes, along with the almost simultaneous introduction of other devices such as hot water heaters, irons and indoor bathrooms meant that the societal expectations of hygiene changed. Why only wash yourself and your clothes once a week when it is now easy enough to do every day? Therefore while the devices individually saved effort, the combination of them collectively increased the amount of

work done in the home [Edwards, 2001]. It is very difficult to predict these changes and consequences in advance, but designers must be aware that they will happen.

The second societal challenge is the one that pertains most directly to my work. This challenge discusses how it is difficult to foresee how technology will be adopted, so it is therefore important to ground the development of new technology in *"the realities of the home" [Edwards, 2001]*. For instance, when the telephone was first introduced, its vendors did not foresee it being used for social calls. It wasn't until several decades later, after it had already been widely adopted, and was already being widely used for social calls, that it was finally promoted as a way to connect to family and friends. The mobile phone has seen a similar pattern. Individuals report buying a mobile phone for safety reason, e.g., being able to call someone if their car breaks down. However, within a week after purchase, they are already using it for social calls [Edwards, 2001]. These uses, unexpected by vendors and even the users themselves indicate a need for study of the domestic environment.

> *"A key research problem in designing for this environment is the need to understand the everyday character of the home: how people live in the home, what they do when they are at home, and the potential role of technologies within the milieu of domestic activities" [Crabtree, 2003b].*

Designers need to study and explore domestic routines to determine how technology fits [Edwards, 2001; Crabtree, 2003b; Taylor, 2005]. However, studying the home presents its own challenges. The majority of studies on technology use have taken place in the workplace. While it may seem obvious to say that the home is not the office, when we look at the computer technology currently being used in our homes, it is almost identical to what we have in our offices. Many homes currently contain at least one PC or laptop, which is designed to be used by one person at a time, sitting at a desk, doing work. However, this is not how people usually function within the home environment. While there is definitely work to be done to keep the household running smoothly, it is not defined or carried out in the same way as in an office [Crabtree, 2003b; Hindus, 1999; Taylor, 2005] , so it unlikely that the same kinds of technology will be a good fit to the home.

In addition, the task-centered approach which is useful in studying the workplace is not as valuable in a domestic setting, where tasks may be vaguely articulated at best [Hindus, 1999]. There are several ways in which homes are fundamentally different than offices, meaning that many of the implicit CSCW assumptions used in studying the workplace are not necessarily true in a domestic setting [Hindus, 1999; Crabtree, 2003b]. For example, families and households are not organised in the same way that businesses are. Roles are vague and implicitly assigned. Decisions are made in a completely different way. Values are very differently chosen. Homes also involve a much broader user base – while offices are primarily occupied by working-age adults, homes may contain children, babies and the elderly [Hindus, 1999; Crabtree, 2003b].

Because of this, studying technology in the home is a multi-disciplinary effort, involving both technology designers and sociologists [Dourish, 2001b; Hindus, 1999]. Techniques borrowed from sociology have been heavily used in studies of the home. These techniques are not pure ethnography, as this would require an observer to live with a household for many weeks. Instead, they are modified versions used specifically to find out about technology use. These include having participants use video cameras or logs on their own [e.g., Crabtree, 2003b; Tollmar, 2002], performing interviews and tours within the home [e.g., Taylor, 2005; Tolmie, 2002] along with more direct observation [e.g., Taylor, 2005]. I will now discuss findings from several studies performed using these techniques.

2.6 Studying the Home

> *"... design may be usefully informed through careful consideration of the ways in which existing technologies, whether technically sophisticated or not, are routinely made to be 'at home' by household members in their everyday interactions so that they come to assume an eventful and purposeful role in domestic affairs" [Crabtree, 2003b].*

The studies previously done by researchers have primarily looked at communication and household coordination, and the routine activities, information and technology uses

associated with those activities. I will discuss the results most relevant to my own research, in order to situate my work within it.

First of all, these studies have shown that communication and interaction activities and artifacts are distributed throughout the home. Artifacts can include mail, email, notes, lists, pictures, address books, phones, calendars etc. Activities could include anything involving these artifacts, e.g. replying to an email, discussing a letter, putting a picture on the refrigerator door, etc. Several researchers have looked at how these artifacts are distributed through the entire home, and how this distribution is related to the activities themselves, and to the social organisation of the household.

Crabtree et al. [2003b] found that communication media and artifacts moved from one place to another in the home as people interacted with it. They called these locations *"places of communication"* [Crabtree, 2003b] and defined three sub-types: Ecological Habitats, where artifacts live; Coordinate Displays, where artifacts are left for others; and Activity Centres, where artifacts are worked with. Household members implicitly understand these places. For example, a husband enters the home after work, picking up the mail on his way in. He takes it into the kitchen to open and sort it. He sees that one is a letter from a college friend, and the other is a postcard from neighbours on holiday. He puts the postcard on the kitchen table for his wife to see, and takes the letter to the computer desk to write an email reply. When his wife gets home, she sees the postcard on the table, picks it up and brings it into the living room where she sits on the couch and discusses it with her husband. She then places the postcard on the windowsill to display it [Crabtree, 2003b]. In this example, the windowsill is an Ecological Habitat (where the card lives), the couch and the computer desk are Activity Centres (where they interact with the card and letter), and the kitchen table is a Coordinate Display (where the card is left by one person for another). The way information flows from one place to another over time is a routine action sequence for this household, and is part of their social organisation. Artifacts and activities are *"...spatially and temporally distributed throughout the home" [Crabtree, 2003b]*.

Rodden et al. [2004] talks about this as the Space-plan and the Stuff of the home. The Space-plan is the interior layout of the home, including features such as the furniture, shelves, floor-plan etc. The Stuff is the artifacts located within the Space-plan. They state that the Space-plan and the Stuff of the home are *"...organizational features of interaction."* The Space-plan *"...does not simply 'contain' action then, but is interwoven with action in various fundamental ways"* while Stuff is *"...dynamic, coalescing around different sites at different times for the practical purposes of the activity at hand" [Rodden, 2004]*. That is, the way that artifacts in the home are arranged, grouped and moved throughout the space of the home during day to day activities forms an organisational system for the home.

These organisational systems are examined in detail by Taylor and Swan [2005]. The communication places in the home – the Ecological Habitats, Activity Centres and Coordinate Displays [Crabtree, 2003b] – are incorporated into larger, overall organising systems, that is, *"heterogeneous collections of artifacts are enrolled to capture, integrate and arrange, and convey information" [Taylor, 2005]*. Taylor and Swan found that the 'work' in the home (e.g., scheduling, errands, carpools, chores etc.) rely on these organising systems. These systems are not static, but are frequently redefined to meet the changing needs of the family, making them very personalised and idiosyncratic.

An example of an organising system is a family calendar described by Taylor and Swan [2005]. This chart contains all of the family's schedule information – trips, babysitting, dinner dates etc. It is part of Mom's morning routine. She will look at the calendar while putting the kettle on for tea. Then, while driving her kids to school, she will tell them what is going on that day. In addition, since Mom is the primary family scheduler, when Dad adds something to the calendar, such as a fishing trip, she may overrule him and cross it out if there is something the family is doing that day.

This system both comes out of and creates the family's routines. It is part of "*...the very business of parenting" [Taylor, 2005]*. It also reveals information about the social organisation of the home – there is, for instance, a hierarchy of what is more important – fishing trips or family events – and who is the final decision maker when it comes to

scheduling. While this system involves only the calendar artifact, other systems frequently involve many artifacts. Even a scheduling system could involve not only a calendar, but school notices, personal daytimers, to-do lists, etc. These artifacts also move from one location to another. The school letter, for instance, may be gathered during a walk home from school, then placed on the sideboard so it will be seen in the course of the evening, and finally taken to the phone for scheduling [Taylor, 2005]. Crabtree et al. [2003b] calls the way that artifacts travel from one place to another "*discreet and recurrent sequences of action" [Crabtree, 2003b]*. The way that mail routinely moves through the home, from coordinate displays, to activity centres, to ecological habitats is an example of such a sequence of action. Harper et al. [2001] found that the way that paper mail can be moved around the house supports the social organisation of the household, and is one reason why email has not entirely replaced paper mail.

The routines that create these sequences are known by all household members, and actually provide them with resources to manage their activities [Crabtree, 2003b]. The activities people do in the morning when they get up, in the afternoon when they get home from work, and in the evening while they plan for the following day *"...provide the grounds whereby the business of home life gets done" [Tolmie, 2002]*. O'Brien et al. [1999] found that *"One of the clearest facets of everyday home life (...) was the importance in all households of 'daily routine', of things 'being as they should be'" [O'Brien, 1999]*. These routines are subtle and ill-articulated, and emerge from the daily ways that households organise their lives.

Technology is often interwoven with these routines, and may even help construct them [O'Brien, 1999]. For example, a certain television program may be watched every morning while the household eats breakfast, with the end of the show marking the time that they need to leave for work [O'Brien, 1999].

The design implications of these findings include such suggestions as the identification of these places (e.g., Ecological Habitats, Activity Centres and Coordinate Displays) as prime sites for ubiquitous computing technology in the home [Crabtree, 2003b]. This could include, for example, using electronic displays to augment activity

centres, or digitally extending Coordinate Displays to be available outside the home [Crabtree, 2003b]. New technology also needs to be able to be situated at the wide variety of sites used for activities within the Space-plan [Rodden, 2004]. This may seem fairly simple, but the wide range of the kind of places used in the home and the current demands of technology – power, space for stands etc. – make this very challenging.

It is also not enough to simply be able to put these devices into the communication places in the home. These devices need to be able to be moved and connected, since artifacts (including the devices themselves) flow from one place to another. It is easy to carry a piece of paper from one room to the next. Technology designed for communication in the home needs to make it equally easy to move digital media [Rodden, 2004]. In addition, every household has a unique set of places, and a unique way of using these places. They are not (usually) system administrators, so the devices need to be flexible and easily configured, as well as simply combined, and connected to other devices [Taylor, 2005]. The nature of action sequences indicates that artifacts could be augmented digitally [Tolmie, 2002], for instance to be aware of where they are located and modify their displays accordingly. Digital media also needs to be designed to be more flexible in terms of how they can be moved from one place in the home to another seamlessly [Crabtree, 2003b]. Technology that can be easily moved, combined and configured would be more likely to fit into, and eventually become part of the daily routines and social organisation of the home, which is where they would have the most value [Taylor, 2005].

2.7 Summary

We now know that Ubiquitous Computing reconsiders how technology can be transformed to better fit our everyday lives and environments. Tangible Computing explains one method of how this can be done, where the properties of physical objects are exploited to display and manipulate digital information in a natural way. Embodied Interaction encompasses these two concepts within a social theory, where interaction should happen within our everyday environment and social practices. Context-Aware Computing looks at how we can make computers more aware of our environment so that they can better support us

within it. The smart home attempts to create such an environment, although they are typically designed around technical opportunities rather than social practices. Still, various technologies and systems have been demonstrated to illustrate point aspects of how social practices can be supported within the home. Finally, studies of home behaviours step back from the technology. They strive to gain a better understanding of the mundane and often tacit aspects of domestic behaviour, where these would be used to inform design opportunities.

While existing research has contributed much to our understanding of the home, we still have a very incomplete picture of the role of technology in domestic life. My work seeks to add depth and richness to this. While previous work has shown that information is used in a very complex way within the social practices of the home [Harper, 2001; Crabtree, 2003b], we still don't have a full understanding of exactly how this works. We also know that technology, while very popular in the home, does not always work well there [Harper, 2001] or replace existing practices, even where it could theoretically provide benefits. For instance, one of the things that technology is very good at is information management, yet it isn't used for that in the home, and we don't know why not. We also don't know what kinds of information are in the home, other than the specific examples described in the related research. Finally, we don't know how people know about the information in their homes – how do they know what to attend to? How do they filter the information down to that which is relevant to them? In this thesis I intend to investigate the use of information in domestic life in order to begin to answer some of these questions, and to add to the understanding of technology in the home that the previous work has begun to establish.

In the rest of this thesis, I will draw on the literature presented here to investigate communication information in the home. My own study is described in Chapter 3, and the results in Chapters 3 and 4. Chapters 5 and 6 describe how I use these results along with the previous research described here to create two prototype home designs.

Chapter 3. Exploring Communication Information in the Home

The proceeding chapter presented the existing literature on how households use communication information and artifacts. Yet it is still not well understood what types of communication information are present in the home, or how household members manage and organise this information. In this chapter[1] I present an exploratory study that I and collaborator Carman Neustaedter performed to better understand the home environment. First, I discuss the methodology used in the study. Next, I present the first part of the study results, consisting of a list of the general communication information types we observed in our participant homes. Finally, I briefly discuss the various media used to present this information. The second part of the study results, presented in Chapter 4, examines how people use locations to manage this information.

3.1 Study Methodology

The study was planned and conducted in partnership with Carman Neustaedter, a PhD student in the Interactions Lab at the University of Calgary. It was composed of two separate phases, which were run one after the other in each participant session. Phase 1 was an investigation into awareness and communication between household members and their friends and families. This phase relates to the work being done by Mr. Neustaedter, and is discussed in Neustaedter et al. [2004]. The second phase of the study is described here, and

[1] A version of the content described in Chapters 3 and 4 is published as:

Elliot, K., Neustaedter, C. and Greenberg, S. (2005) **Time, Ownership and Awareness: The Value of Contextual Locations in the Home.** In *the Proceedings of Ubicomp 2005*. ACM Press, 251-268.

led to the results described in Chapters 3 and 4. While the study organisation was done as a partnership, we each took responsibility for conducting the phase of the study more related to our interests, and independently did the analysis for each phase. Detailed descriptions of both phases are available in Appendix A.

More specifically, in phase 2 we were interested in gaining an understanding of how households and individuals currently handle communication information in their homes. We wanted to know what communication information is present and manipulated by inhabitants, and how this information is managed and handled. For simplicity, from this point forward we use the terms communication information and messages interchangeably.

3.1.1 Participants

We recruited and interviewed 29 people (sixteen female, thirteen male) within the context of ten different households, all in the same large Canadian city. We recruited participants through various email mailing lists, system "message of the day" notes, and a community band newsletter. From the responses, we selected intentionally diverse households to provide a broad range of household size, composition and demographics.

Household size ranged from one to four people, including children and adults. We interviewed roommates, common-law partners, divorced parents with shared custody, married parents with school aged children, working couples with teenagers and retired couples with adult children. Participants included five teenagers, sixteen young-mid adults (ages 20–39) and eight middle-aged adults (ages 40–60). For pragmatic reasons, we did not interview children under the age of twelve. Participants were from a wide variety of backgrounds; including students, retirees, programmers, teachers and office administrators. Most were moderately to very technically inclined. Their homes also ranged widely in physical size and architecture from small one bedroom apartments to large 4-5 bedroom houses. Table 3.1 contains a detailed break down of participant demographics.

Home	Person	Age	Relationships	Occupation/Scholastic Grade
1	A	21	Common law partner of B	Undergraduate student
	B	29	Common law partner of A, parent of C	Undergraduate student
	C*	8	Son of B, lives with A & B every second weekend under shared custody	Grade 3
2	D	41	Mother	Undergraduate student
	E	15	Son, lives with D half of each month	Grade 10
3	F	32	Spouse of G	Programmer
	G	31	Spouse of F	Master's student
	H	30	Roommate	Undergraduate student
4	I	22	Sister	Computer consultant/part-time undergraduate student
	J	24	Sister	Operator/part-time undergraduate student
5	K	22	Son	Undergraduate student
	L	27	Son	Master's student
	M	55+	Mother	Retired teacher/homemaker
	N	55+	Father	Retired engineer
6	O	14	Son	Grade 9
	P	16	Daughter	Grade 10
	Q	50	Mother	Music Teacher, from home
	R	57	Father	Engineer
7	S	28	Brother	Master's student
	T	26	Brother	Undergraduate student
	U	24	Brother	Undergraduate student
	V	20	Sister	Retail employee
8	W	15	Daughter	Grade 9
	X	17	Son	Grade 12
	Y	48	Father	Contract Administrator
	Z	49	Mother	Office Administrator
9	AA*	11	Daughter, lives with CC & DD every second week under shared custody	Grade 5
	BB*	14	Son, lives with CC & DD every second week under shared custody	Grade 9
	CC	45	Father	Computer Programmer
	DD	49	Step-mother	Child caregiver, from home
10	EE	21	Roommate	Undergraduate student
	FF	21	Roommate	Undergraduate student
	GG	22	Roommate	Undergraduate student

Table 3.1 Study Participant Demographics (*indicates that they were not interviewed)

3.1.2 Method

We used a series of semi-structured contextual interviews [Holtzblatt, 1995] that took place in each household's home. We asked all members of the household to show us what communication information they used, and where this information was located in the home. We provided a deliberately vague and open definition of communication information so that we could see what they considered it to be. We toured the home and photographed this information within their locations, asking questions as we went. Examples of the types of questions we asked and our interview protocol is available in Appendix A.

Our goal for each interview was to see what types of information were present in the home and to understand a person's explanation about the message type, its medium, and its location. These explanations would suggest what meta-data people use to help them decide how to handle the information they come across. Depending on what participants showed us and their responses, our interview then focused on asking questions whose answers would give us a better understanding of the uses or goals of the kinds of information present, why participants had chosen the various information locations, and when participants would typically access or interact with the information.

3.1.3 Analysis

We analyzed our interviews and observations using an open coding technique [Strauss, 1998] to reveal similarities and differences between participant households. That is, for each instance of information, artifact and location seen, we looked for patterns and repetitions in what kind of information was present and how it was handled. When a pattern became evident we marked each occurrence with a code (a descriptive label). For example, when we saw a reminder, we would mark it with an [R] code. Subsequent reminder examples would also be coded [R]. Once the data was coded, we then looked for larger patterns occurring between the codes.

In general, we found that in spite of the diversity of our participant demographics, household compositions and home architectures, there were many commonalities in the types of messages present and in how this information was managed. I present these results in subsequent sections, beginning with the types of communication information present in our participant households.

3.2 Communication Information Types

In looking at the patterns and similarities between households, we found five general categories of communication information in the home. These are summarised in Table 3.2. We distinguish these categories in terms of how the information was used or its intended purpose:

4. **Memory Triggers** are intended or used as time sensitive memory support.
5. **Member Awareness** information provides knowledge of the activities and whereabouts of household members.
6. **Exhibits** are to be shared, noticed or admired.
7. **Notices** provide household members with information about activities or people outside the home.
8. **Resource Coordination** information is used to coordinate the sharing of common household resources.

These five categories are not mutually exclusive; a single piece of information may fall into several groupings. For example, a shared grocery list could be both a to-do list (Memory Triggers), and a way to coordinate sharing of duties (Resource Coordination). Finally, these categories describe and contain all of the instances of communication and coordination information we saw in our participant households. Every household we interviewed had at least one and usually many more examples of each category. I will now explain each category in more detail, using examples and images from our study participants.

Information Type	Subtypes	Goal/Characteristics
Memory Triggers	• Reminders • Alerts • To-do Lists	• Intended or used as time-sensitive memory support.
Member Awareness	• Awareness • Scheduling	• Provides knowledge of the activities and whereabouts of household members.
Exhibits		• Information to be shared, noticed or admired. • To remind the household of recent events or achievements. • Infrequently updated.
Notices	• Active • Informative	• To provide household members with information about activities or contacts outside the home. • Practical information that is frequently updated.
Resource Coordination		• Used to manage the sharing or consumption of a common household resource.

Table 3.2 Summary of the Five Information Types

3.2.1 Memory Triggers

The most common type of information present in the home is Memory Trigger information. This category includes anything intended or used as time sensitive memory support. This includes to-do lists, reminder notes or emails, instant messages, or warning tags. We saw three main sub-types of this information: *reminders* that remind people about things they know but may forget, *to-do lists* that contain a list of things that must be done and *alerts* that remind or inform people of immediately critical information.

This category is highly time-sensitive. We saw that the value in these messages came from *when* they were seen. People use messages in this category to convey information *at the right time*, whether this time is related to the urgency of the message (e.g., a reminder to call the shop right away, since it closes early), or to its relevancy (e.g., remembering what errands you need to run on the way home).

An example of this category is visible in Figure 3.1a. Here, a mother wanted to remind her son that he is to put dinner in the oven when he arrives home from school. She placed this reminder note on the son's computer monitor because there is some urgency to it – it needs to be done right when he gets home, or dinner won't be ready in time. To foreshadow the role of locations, she knows that her son will see this at the right time, as his routine on coming home is to go to his computer to check his email. A second, very

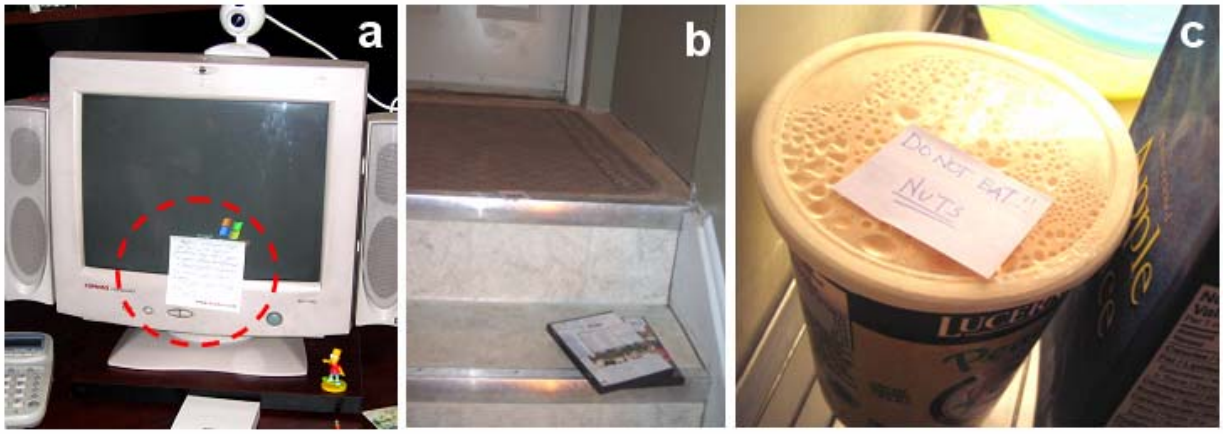

Figure 3.1 Examples of Memory Triggers

typical example of a reminder is shown in Figure 3.1b. Here, we see two DVD movies that need to be returned. The movies are placed on the step by the door, where they will be seen upon leaving the home, so that they are not forgotten. Thus the artefact itself becomes the reminder. Finally, an example of an alert, shown in Figure 3.1c, is a post-it note stuck on a container of food in the fridge, warning a roommate with allergies to the presence of nuts. It is an alert, rather than a reminder, as the roommate needs to see the message before she considers eating the food, and this is critical information – if she misses the note, she will get sick. In general, the timing of this type of messages is crucial – the information depends on when they will be seen or received.

3.2.2 Member Awareness information

The second most common type of communication information present in homes concerns Member Awareness. There are two main subtypes of this information. The first is *awareness* information. This is used to maintain an understanding of the presence and activities of household members, e.g., this information is used to know who is currently home, who is still at school or work, where people are in the home, what others are currently doing, etc. The second subtype is *scheduling* information. This includes items such as one's calendar activities or time schedule, e.g., what time someone will be returning to the house, what date someone will be going out of town, etc. Both awareness and schedule information involve knowing details about the day-to-day routines and timetables of household members.

While Member Awareness information is not as time sensitive as Memory Triggers, it is still critical to the smooth functioning and micro-coordination of the household and the comfort of its inhabitants. Its goal is to provide people with knowledge of the whereabouts and activities of others. For example, we saw that this information is particularly important for families with children, where parents need to coordinate who drives the children to their various activities. A more mundane example is using schedule information to coordinate carpools, or to decide on a date for a family event. While some of this information is left or gathered explicitly (e.g., as a note in a central common location such as the kitchen table),

other times it is left implicitly through routine actions and gathered peripherally (e.g., the presence or absence of cars or shoes).

Figure 3.2a illustrates a common scheduling artefact, a family calendar. On this calendar, events for members of the household are explicitly written down so that they are not missed or forgotten, so that other family members know what is going on, and so new events can be planned while avoiding conflicts. Using the example above, this may include a ride schedule so parents know who needs to be picked up and where. As a second example, Figure 3.2b shows an entryway to the house where guests leave their shoes, where the presence or absence of shoes acts as an implicit awareness message. Since members of this household enter through the garage, they know that shoes or jackets in the front entrance mean that guests are present in the home; they may even be able to identify guests from their shoes.

Figure 3.2 Examples of Member Awareness information

3.2.3 Exhibits

Household members often set up information to be shared, noticed and/or admired. Examples include the display of birthday cards, postcards or letters from friends or family, pictures from recent events, awards and achievements, comics or articles to share, or children's artwork. We call this category of information Exhibits.

Figure 3.3a shows a mantle in a family room containing family pictures, recent birthday cards, awards and medals, as well as children's artwork and vacation souvenirs. These are all pieces of infrequently updated information that the family wishes to display in a public location, where they attract the attention and comments of both household members and guests, and remind the family of shared events or achievements. Other common examples include postcards and pictures displayed on the fridge (e.g., Figure 3.3b), anniversary cards on the hall table (e.g., Figure 3.3c), and funny comics taped up in the computer room.

3.2.4 Notices

The goal of Notices is to provide household members with information about activities or contacts outside the home. Notices include newsletters, forms or letters from school, mail, etc. There are two subtypes of Notices: *active* and *informative.* Active Notices are

Figure 3.3 Examples of Exhibits in the home.

somewhat time sensitive. They require a response, or some other action. The most common example of this category is phone messages, but it also includes school notices that need to be signed, or mail that requires a reply. Informative Notices also provide information about contacts or activities outside the home, however they do not require a response. This could include things like the latest church bulletin, school newsletters, family Christmas notes, etc. The defining characteristic of a Notice is that it is about something outside the home. Figure 3.4a shows a family bulletin board covered in both types of Notices, including bulletins and newsletters from work, school and the children's activities. Phone messages and important numbers are seen in the top left hand corner of the board. This information keeps the family aware of what is happening with their outside activities and contacts. Figure 3.4b shows a similar display constructed on a counter (a very common place for this type of information) that includes mail, school notices, and pictures. As with Exhibits, this category of information is often shared between home members and publicly displayed; however, its content is more practical and more frequently updated.

Figure 3.4 Examples of Notices in the home

3.2.5 Resource Coordination

This final category includes any information used to manage the sharing or the consumption of a common household resource. For example, Resource Coordination items may include shopping lists, financial data, charts for sharing chores, bills to be split among roommates, or notes on food that is not to be eaten by others. Items from this category are less common, but still present in every home we visited. Figure 3.5a illustrates how two roommates coordinate the sharing of groceries: on the left of the fridge door is a shopping list; on the right side is a receipt for the recent grocery purchases. Figure 3.5b shows a similar fridge door list used by siblings to share out unpleasant household chores, such as changing the cats' litter.

Figure 3.5 Examples of Resource Coordination Information

3.3 Information Media

We also saw that people choose many different media for the information in their homes. Electronic and paper based media as well as the position of the artifacts themselves are commonly used to communicate our five information types.

What we found in talking to people about how they chose what medium to use was that the medium of the message has very little to do with either the information itself or with the management of that information. There is not, for example, one medium that is used only for reminders, or another that lets people know what is important or current. We found that when people have a choice of media to use, the selection of medium is based on the comfort level of the medium for the sender and recipient (especially in the case of electronic media), the convenience of the medium and the affordances of where the message is to be left. The information medium is not relevant to information type or to information management, but is instead relevant to the message's placement, sender and recipient. For example, the most common medium seen in our study was the sticky note – these can be placed just about anywhere, are quick and convenient, and the vast majority of people are comfortable with scribbling and reading quick notes. We did see electronic media, such as email, instant messaging, etc. being used, however they was not as common as paper-based media – electronic media are usually more time consuming to use, are restricted in where they can be used, and many people are not comfortable with them. In fact, electronic media can create a barrier to the household's natural information management system. We further discuss this in Chapter 4.

3.4 Summary

In summary, we interviewed ten households about the communication information present in their homes and how they managed it. By looking for patterns in the data through open coding techniques, we found five generic information types. These were present in all our participant households, and are summarised in Table 3.2. We also saw that the medium

used for a particular message was chosen based on comfort, convenience and the affordances of the intended message location, rather than choosing a medium based on the type of information or as a way to manage it.

However, these five information types do not tell the whole story. There is another major pattern that we found in the data called *contextual locations*. As we will see in the following chapter, this method gives households the ability to cope quickly with and to understand the information in their homes.

Chapter 4. Contextual Locations

In the proceeding chapter, I presented the first part of the results from an exploratory study done to better understand the types and management of communication information in the home. This consisted of a list of general information types present in the home that practitioners can use to better decide what information to design for in the home environment. In this chapter, I will focus on the management of this information – that is, how people determine what messages need their attention at what times[2]. First, I will present a set of questions that guide people's understanding of the communication information in their homes. Second, I will use these questions to show how people employ *contextual locations* in their homes to manage messages. I will then present how these locations are initially established, and how they are distributed throughout the home. Fourth, I will discuss exactly how these locations provide household members with *time, ownership* and *awareness* information about the messages within them. I will then briefly examine how the idea of contextual locations extends and confirms some of the related work discussed originally in Chapter 2. Finally, I will discuss how the information types from Chapter 3 and contextual locations provide new opportunities for practitioners to design better information systems for the home. In Chapters 5 and 6, I will present two examples of designs that begin to exploit these opportunities.

[2] A version of the content presented in Chapters 3 and 4 is published as:

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4.1 Guiding Questions

While discussing the communication information found in people's homes with the household members, we found that people would naturally provide a four part answer when generally asked about a specific piece of communication information:

1. What is it? What is this information about, what is it related to?
2. Whose is it? Who needs to pay attention to it? Should I pay attention to it? Is it mine? Who else needs to see it?
3. What needs to be done with it? What actions need to be taken?
4. When do I/others need to interact with it? Is it urgent? At what point in time will I/others need to interact with this information?

For example, a typical statement would be "Well, that's a phone message (question #1) for my mom (#2), and she needs to call them back right away (#3) so she needs to see it when she comes home. (#4) ". These general questions provide a valuable understanding of how people organise, understand and manage the vast quantities of communication information in their homes.

In trying to understand how people could rapidly answer these questions, we saw that every household we looked at had a set of key locations (places) that inhabitants used for displaying, interacting, organizing and coping with communication information. We found that these places within the home were more than they initially seemed to be. No matter what the answers were to what is it, who is it for, when do they need it or what needs to be done for a given piece of information, when we asked people "How do you know?" they would almost always reply with some variation of "Well, because it is on the fridge" or "…in the doorway" or "…on her placemat". *People place messages in different locations within their homes to give the messages more meaning*. These locations gave them the answers they need to allow them to filter and manage the communication information in their homes.

These places provide household members with important meta-data about the communication information located there. This meta-data includes time information, ownership information and awareness information. Places are what enable people to answer our guiding questions for each message: whose is it, what needs to be done with it, and when do I/others need to interact with it. In this way, space is interwoven not only with action [Rodden, 2004] or with what people are doing with the message, but also with this rich context and meta-data about the messages they choose to place there. We call these places *contextual locations*, since they provide the information in them with context, and therefore richer meaning.

I will first describe how these places for information are initially selected. I will then describe the ways these chosen contextual locations afford *time, ownership* and *awareness* to the information placed there.

4.2 Location Placement in the Home

We consider contextual locations to include any place where communication information was placed. These could be static (e.g., the kitchen table) or dynamic (e.g., a day planner carried in a purse). The number of locations in a home varied widely. One participant household had only four locations they used for communication information, while another had 23 separate locations. The average number of locations per household was just over 15; in fact, 60% of our households had between 13 and 17 locations.

The number of distinct communication information locations per household appears to be determined by two separate factors. The first is the physical size of the house: we found that the larger the home, the more locations present. In fact, the smallest home we studied had the fewest locations and the largest had the most, though there were many variations in between. The second factor is the number of independent adults in the household. The presence of children does increase the number of locations, but not as significantly as the presence of another adult. For example, a household consisting of a divorced mother and her 15 year old son had far fewer locations than a similar sized home

inhabited by two adult roommates. However, couples tended to have fewer locations than two unmarried friends or roommates, because couples typically have very entwined lives.

The number and placement of these locations is part of the home ecology, in that it is a shared household understanding that develops over time. To illustrate, one participant household contained a group of roommates who had been living together for only a few weeks. While each had a good understanding of places for their individual information, the shared locations were not yet well formed or understood. Insufficient time had passed for the meaning and use of these locations to evolve into a full shared understanding.

Through their everyday routines, households implicitly select locations in order to provide answers to the four information questions. These locations develop social meaning over time, and become a strong shared language in the home. *People rely on their knowledge of home routines (their own and those of others) as well as the placement of main traffic paths, common areas and personal spaces to find suitable places for information.*

In the next few subsections, I discuss the specifics of how this understanding of routine leads to the selection of certain locations for information management. This is summarised in Table 4.1.

Pathways and Routines	Household members use their knowledge of routines and pathways to select information placement. Information locations may create or establish new routines.
Constellations	Information locations tend to group themselves so that other relevant information and useful technology is nearby
Visibility versus Practicality	Location has such great value in terms of providing visibility, organization and relevance that it overrides more practical considerations.

Table 4.1 Influences on Location Placement

4.2.1 Pathways and routines

Information locations tend to group themselves along pathways through the house [Crabtree, 2003b], for instance the path from the front door to the kitchen. Since these are routes most of the household will pass through over the course of the day, they are chosen as places to leave the information people need to or want to see. Part of this is derived from familiarity, where people know the routines of other household members—what they do when they come home, where they go, where they leave things like keys or purses—and use this knowledge in deciding where to leave messages. As Tolmie et al. [2002] found*: "Routines are resources for action, and knowledge of others' routines can be resources for interaction."*

To illustrate, in one of our households, the teenage son enters through the front door, passes through the kitchen, and then goes down to the basement. Parents leave notes for him on the kitchen counter since he has to pass by it on his way to the basement stairs. Knowledge of his routine, as well as the pathway he takes from the entrance way to the basement, meant that this was the logical spot for his parents to place this information. *Household members use their knowledge of routines and pathways to select information placement*.

Once these locations are established however, they themselves become an element in daily routines. For example, many of our participants would describe locations they would explicitly check for information as part of their routine upon arriving home. These would include locations such as the area near the answering machine or the surface of the kitchen table. *Information locations may create or establish new routines*.

4.2.2 Constellations

Areas also tend to be grouped. One communication area will normally cause other ones to form nearby, since it is often convenient to have different kinds of communication information in close proximity. We call these location groupings constellations, since they consist of many unique locations linked by common activities or subjects. For example, if

the kitchen counter is used to organize coupons and flyers, other locations such as the family grocery list will usually be nearby. Constellations are most often present in common, frequently visited areas of the house, such as the kitchen, family room, entrance way, etc.

In addition, communication media and technology such as phones and computers also attract communication information. Since this technology is less portable, information typically comes to them. Since locations group together as we described above, constellations will often form around these areas. For example, phone messages usually go next to the phone since that is where they were created. Calendars are also usually near the phone, so that people can check their schedules when making plans with others on the phone. Other types of information, such as school newsletters, are needed near the calendar as they augment its event scheduling information. This cascading effect of interlinked information creates an information constellation around the phone.

An example of a constellation from one of our participant households is seen in Figure 4.1. In Figure 4.1a, we see a refrigerator covered in family photos and postcards. On the wall next to the fridge is the family calendar, along with notes about appointments (4.1b). Across a doorway, but within easy reach, is the main household phone, right next to the family bulletin board (4.1c). The bulletin board is covered with newsletters, schedules, fast food menus – information that is handy when scheduling, organising carpools, ordering dinner, etc. Phone messages are also left on this bulletin board. Next to the bulletin board is a countertop where items that are actively being worked on are left (4.1d). This could include letters to be signed, bills that still need to be paid, mail that has just been opened, etc. These four areas have all grouped together, as information from one area is often useful or relevant to information in a nearby area, e.g. the calendar, the phone and the schedules on the bulletin board. *Information locations tend to group themselves so that other relevant information and useful technology is nearby.*

Figure 4.1 An example of a four locations that form a constellation

4.2.3 Visibility versus Practicality

The fitness of a location for communication often dominates other seemingly more practical factors. For example, it may be more practical to put new information in a location that has the space for it instead of an already heavily used information-crowded location. But this is not done. For example, there may be ample space in the basement for school handouts or church newsletters, but because the basement is not a commonly frequented place, information might be missed. Instead, it is added to the already busy central bulletin board. While it takes up much needed space, competes for attention, and gets in the way, it is more visible and easily accessed. A second example would be placing a DVD that needs

to be returned on the first stair leading down to the entryway as all household members will see it (and perhaps trip over it) as they go by, even though it might be less hazardous to leave it by the TV. *Location has such great value in terms of providing visibility, organization and relevance that it overrides more practical considerations*.

4.3 Time, Ownership and Awareness

The above attributes and groupings described how people choose locations to communicate with members of their household; these locations become part of the household's shared language. Next, we will see how choice of location adds valuable information to each message as meta-data regarding time, ownership and awareness. This section is summarised in Table 4.2.

Time	Urgency and Relevance	*Locations provide a vital means for people to convey time-related relevance and urgency.*
	Information Dynamics	*Locations provide a sense of the dynamics of the information, including status, associated action status, temporality and relevance.*
Ownership	Spatial Ownership	*Spatial ownership (implicit or explicit) indicates or implies information ownership and responsibility.* *Spatial ownership may have routine variations based on time and activity.*
	Actions	*The location of information implies intended actions and responsibility for those actions.*
	Visibility and Privacy	*The visibility of the location of a piece of information implies its privacy level.*
Awareness	Presence	*The presence or absence of an object in a routine location can provide awareness information to household members about other members' whereabouts and activities.*
	Monitoring	*Household members use locations to monitor and help each other.*

Table 4.2 Contextual information provided by locations

4.3.1 Time

One primary way locations add information is in timing, where time attributes—urgency, relevance, when it needs to be seen or used, the dynamics of the information—are all conveyed by the location in which the information is placed. This helps people answer the question *when do I/others need to interact with this information*.

Urgency and relevance

There is a definite correlation between location choice, and when information will be needed or when it needs to be seen. One of the most frequently stated reasons for location choice by our participants was the need for the information to be seen at a certain time. This time could be when one eats breakfast, or leaves the house in the morning, or sits down to watch TV. People use their knowledge of the routines of themselves and others to know where to put information so that it is seen in a timely and useful way.

Household members use this knowledge to convey urgency in a message, to make sure information is at hand when needed and to provide a type of priority system for themselves and others. For example, messages from a working mother to her teenage son were usually left on the door to his room, where the mother knew it would be seen at some point. However, as seen in Figure 4.2a, she would place urgent notes on the TV screen instead, as she knew her son would surely see it as soon as he returned home, since the first thing he does after school is watch TV.

This information also works for recipients of information. Household members know when there may be messages for them at certain locations, and what those locations imply about the urgency of a message. For instance, upon arriving home from school or work, people typically have a set of places they will check either implicitly or explicitly for information. If there is nothing in these locations, they assume there is nothing they need to address. If they see something in a location that implies urgency – such as the son as the TV screen – they know that this is something that they should look at right away.

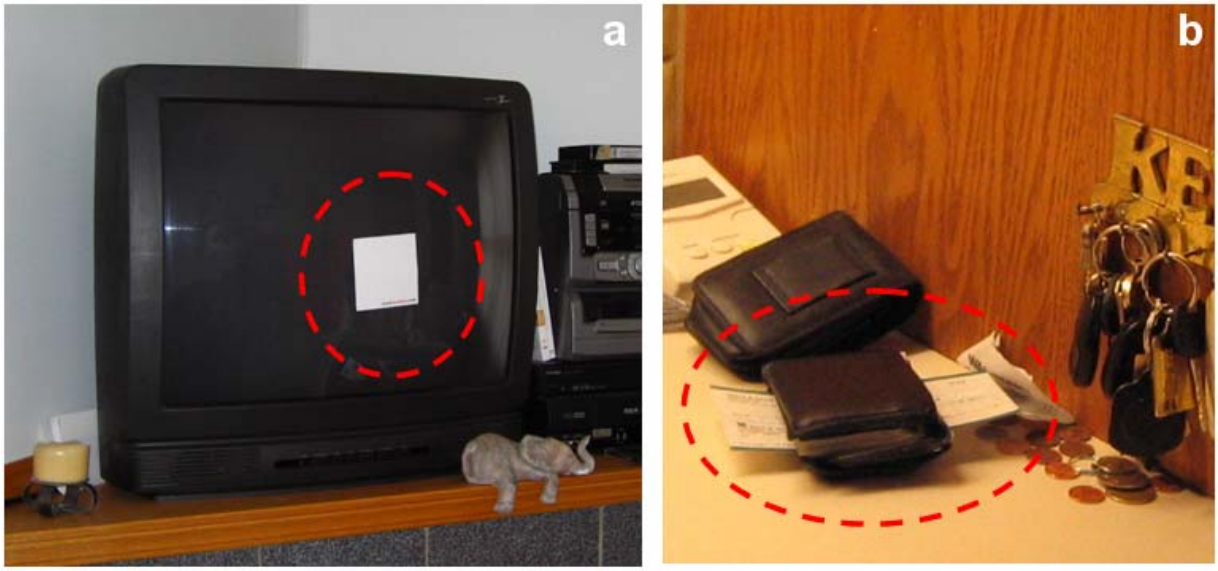

Figure 4.2 Locations can provide urgency and relevance information

.

As another example, the placement of information is very frequently used to create timely reminders. Figure 4.2b shows how household members leave things that need to be mailed with one person's wallet and keys (e.g., the letter tucked into the wallet), itself a part of the key rack constellation, so that he sees them when he picks up his keys to leave in the morning. Another example of this was seen in Chapter 3, where DVDs that need to be returned are left on the step by the entrance to the home. This type of implicit reminder, done by leaving things where they will be noticed at the right time, was very common in all households. *Locations provide a vital means for people to convey time-related relevance and urgency.*

Information dynamics

We also found that information will change location over time as its dynamics change. This includes relevance to other messages, whether or not actions associated with that information have been taken, whether the message is still useful, and its temporality (e.g., is it a new message or an old one).

We saw that as information becomes less relevant or is dealt with, it is often moved to a new location. For example, when bills first arrive in the home, they are usually sorted and

left for the person who pays them. This person will then open them, and move them to a second location, for example, the computer, in order to remember to pay them online. Once the bills have been paid, they are moved to a third location for storage, a filing cabinet for example. This is true of much information that moves through the home—postcards and pictures may be placed in one location until everyone has looked at them, then in another place for long term storage or display.

For example, in one household, members left phone messages as sticky notes on the outside of a cupboard door above the main household phone (Figure 4.3a). After dealing with a message, the member may throw it out. However, if the member needs to keep the message, e.g., contact information that one does not wish to lose, it may be placed on the inside of the cupboard door for a kind of longer term common archive (Figure 4.3b). The household knows that messages on the inside of the door are there for storage, while those on the outside still need to be dealt with. In this way, *locations provide a sense of the dynamics of the information including status, associated action status, temporality and relevance.*

Figure 4.3 An example of how locations can indicate the status of messages

4.3.2 Ownership

One of the most important and most pervasive ways in which we saw location used was to implicitly or explicitly attach ownership to information. Not all information within the home is relevant to all members, so households use locations to define who information belongs to. This allows people to not only manage complexity, but to answer the questions *whose information is this* and *what needs to be done with it*.

Spaces

Each location within the home has an owner—this could be either the person who the space explicitly belongs to (e.g., a child's bedroom) or an implicit owner (e.g., Mom always works in that spot at the kitchen table, so it has become her spot). The knowledge of who a space belongs to is used to not only decide where to leave messages, but also gives members an understanding of which messages belong to them, and which information they are expected to act upon. Ownership of the space implies ownership of the information and responsibility for it.

We found four main subtypes of location ownership within homes**:** *public spaces, public subset spaces, personal spaces,* and *private spaces.* These are summarised in Table 4.3. Public spaces are those owned by everyone in the home. For example, the main house

	Information there belongs to…	**Information can be left there or seen by…**
Public spaces	All household members	All household members
Public Subset spaces	A subset of the household (usually a couple)	All household members
Personal spaces	One household member	All household members
Private spaces	One household member	The owner

Table 4.3 Spatial Ownership

phone or the fridge door are usually considered public spaces, and messages affixed on or near them may be for anyone. Figure 4.4a shows a fridge door used as a public space, where everyone can see it, place items on it, and interact with those items.

Public subset spaces are those that are public, but only to a subset of household members. Couples within a mixed household or parents in a family home typically have public subset spaces: spaces that are public and shared by them, but that do not belong to others in the home. Figure 4.4b shows a desk shared by parents in one of our participant homes. The parents leave a shared calendar for each other to see and use, along with bills, notes, and other shared information. They know that their two adult sons do not look at, write on or otherwise interact with this information. The sons know that these messages are

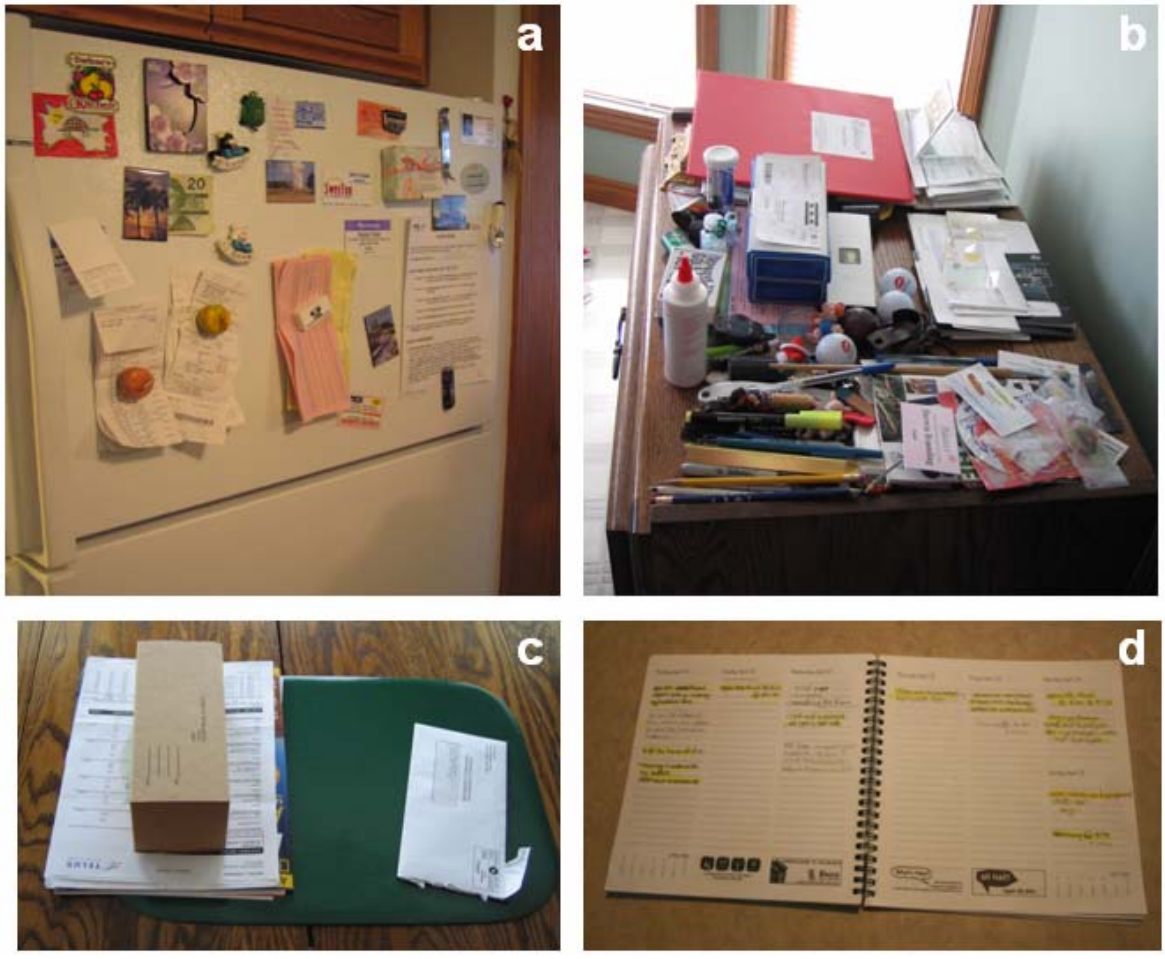

Figure 4.4 Spatial Ownership

just for their parents because they are located in their parents' space. However, if they have events that they want their parents to note, they may leave a note for them with the calendar; or they may leave other messages or information for their parents in this space.

The other two types of spaces belong to individuals, where information within them is understood to be for the owner only. The first type is personal spaces: publicly visible spaces intended for only one individual. These could be the door to a bedroom, a spot at the kitchen table, a computer desk etc. Other members of the house will leave information in these places for the owner, and the owner will leave information there for themselves. Figure 4.4c shows one person's 'personal placemat' containing items placed there by that person for their own use. And because it is a publicly accessible space, others have left mail there for this person to see and act upon (right side of Figure 4.4c).

The final type is private spaces. These are spaces intended for only one individual and not publicly visible or usable by others: day timers, purses, bedroom bulletin boards, etc. Information left in private spaces by its owner usually consists of personal reminders, personal scheduling and contact information. Its owner typically does not expect others to see information in these locations, such as the personal agenda of one household member illustrated in Figure 4.4d. The scheduling information contained in the agenda is for her own purposes only, and is not intended to be seen or understood by other members of her household. Through the same awareness, other members of the household would never consider writing a message in this agenda – it is understood to be a private space.

Knowing who the space belongs to gives household members a quick way to understand whether or not the information located there is something they should pay attention to. It also helps them decide where to leave information that others need to be aware of or take action on. *Spatial ownership (implicit or explicit) indicates or implies information ownership and responsibility.*

Spatial ownership may also vary by time or activity. For instance, O'Brien et al. [1999] found that users of a technology would often 'own' or control the space around it. For example, someone watching TV in the living room temporarily controls that space, and may displace other activities taking place in that room, such as a noisy board game, or

someone wishing to study in peace. We found that if this shift in ownership is routine, information placement may become a part of it. In Figure 4.1, we saw our earlier example of a mother leaving an urgent note for her son on the screen because she knows that he will watch TV soon after he gets home from school. He owns the TV space at this specific time, so notes needing to be seen at that time and pertaining to him will be left there. He also knows that notes stuck on the TV screen at this time are his. *Spatial ownership may have routine variations based on time and activity.*

Actions

The location of a piece of information implicitly attaches intended or expected actions to it. Often information is placed in a certain location so that a member of the household will know they are expected to do something with it (also observed by Crabtree et al. [2003b]). Using previously mentioned examples, this may be a letter to be mailed placed by car keys or a stack of bills to be paid placed by the computer.

Seeing a message in a certain location lets people know what they are expected to do with it. This may be a simple reminder to oneself, as in the example of a person putting a video to be returned by the door, so they can see it as they leave and infer that it is ready to be returned. This is one direct way space is interwoven with action, as in Crabtree et al's Coordinate Displays [Crabtree, 2003b; Crabtree, 2004].

Location ownership indicates responsibility for these actions. People will place information for others in locations that "belong" to that person as a request for action. For example, a child may place a school notice for their parent to sign on the parent's desk. Personal reminders are often left in personal or even private locations. Action triggers placed in public areas, such as the DVD return example above, can be taken care of by any household member. *The location of information implies intended actions and responsibility for those actions.*

Visibility and privacy

We also found that the visibility of the different locations within the home implies not only information ownership but also the privacy level of the message. Information that

household members do not need or necessarily want others to see will be placed in locations that are less visible and therefore more private. Information to be shared with others (e.g., awards, pictures, messages to all) is put in the highly visible and publicly accessible locations. Household members use this in order to protect their own privacy and to protect that of others when it is needed. For example, a husband may leave a message for his wife from the doctor tucked in her purse, rather than on the kitchen table where their houseguest may see it. They use this knowledge to know when information has been placed somewhere for sharing, or when this information is more personal and sensitive. *The visibility of the location of a piece of information implies its privacy level.*

4.3.3 Awareness

Finally, locations include meta-data for communication information by providing awareness information for family members. Awareness information for home inhabitants is very important to people for scheduling, coordination and comfort, as described by Neustaedter et al. [2004].

Presence

The presence or absence of an object from its routine location provides information, especially awareness information. For instance, many of our participants mentioned knowing whether or not someone was home by the presence or absence of their cars in the garage or on the street. What shoes were in the entry way or what keys were on the key rack was also frequently cited as a way of knowing who was around, including whether or not guests were there.

Figure 4.5 shows how one of the participant households evolved a particularly rich system for handling awareness information. Each member of the household would wear different coloured slippers while in the main floor of the house, as it was tiled and cold on bare feet. These slippers would be left in the main entryway (Figure 4.5a) when the wearer was not in, or at the foot of the stairs when they were upstairs in the carpeted area of the home (Figure 4.5b). In this way, family members always knew who was home, and their

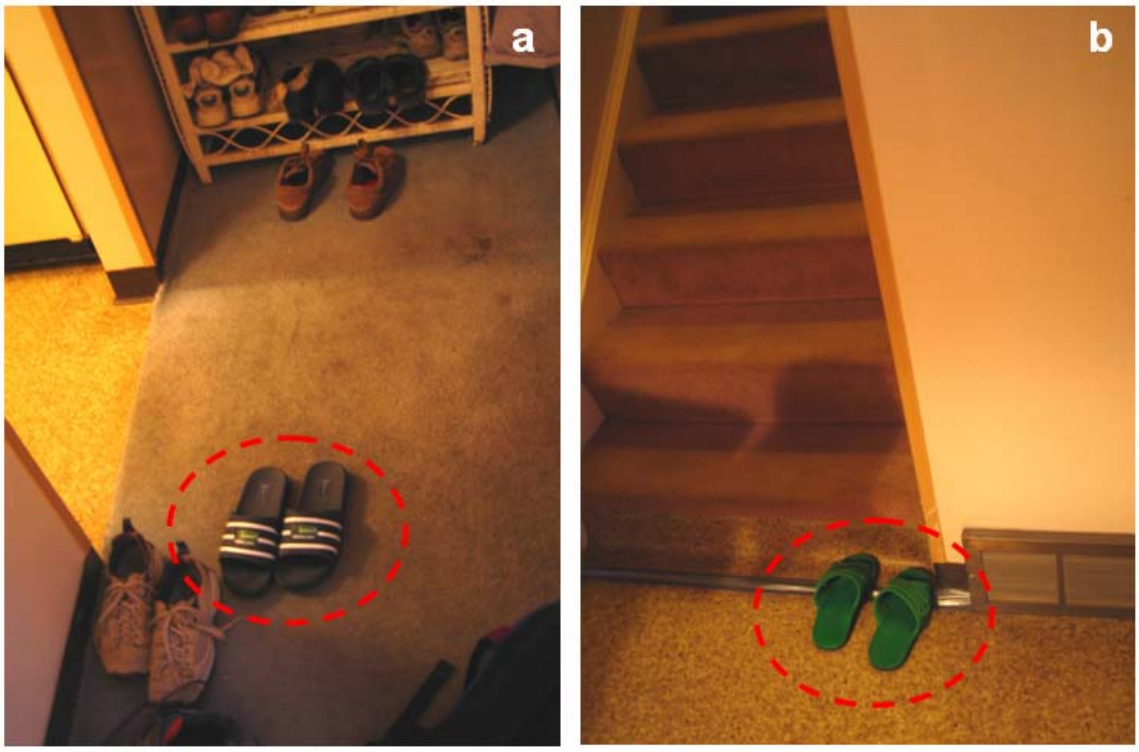

Figure 4.5 Slippers indicate presence and location

general location in the house. *The presence or absence of an object in a routine location can provide awareness information to household members about other members' whereabouts and activities.*

Monitoring

The above assignment of actions through locations combined with the information gathered through the presence or absence of artifacts also works as a form of internal monitoring. Household members know whether others have completed their tasks because they can see what information is present in which locations. This is discussed by several previous authors, e.g. [Harper, 2001; Hindus, 2001; Tolmie, 2002]. Harper et al. [2001] calls this workflow control or workflow management. While the home is definitely not as work-oriented as the office, there are still jobs that must be done to keep the household running smoothly. One example is a wife seeing that her husband has not paid the bills yet since they are still in a pile on the corner of the desk, instead of being filed. She knows he has been busy, so she takes on the job of paying them herself. He then knows she has done this

because the bills have been moved. A second example [Harper, 2001] is parents placing their teenager's cell phone bill in the doorway to his bedroom to make sure he sees it. Once they know he has been home and has therefore seen it, they can then ask if he has paid it – he has become accountable for it because they know he has to have seen it. *Household members use locations to monitor and help each other.*

4.3.4 Locations as attributes and indices

These location types, as well as the information categories discussed in Chapter 3, could perhaps be considered as attributes rather than strict categories, as one location or one information type may serve many purposes. Rather than looking at a piece of information or a location and aiming to categorise it strictly, what we are aiming to do is understand the variety of contextual meta-data people get from the location. Of course, our attributes are not the only ones available. There may be other, more subtle or more personal attributes that people attach to information or to locations that we did not see in our study, but which would be equally valid, and which would fit within and enhance those that we have defined.

Contextual locations may also be enriched by examining them in light of *semiotics*, the doctrine of *signs* [Ferreira, 2005]. Here a sign is something that stands for something else. There are three ways in which signs are related to the objects or concepts they refer to. *Symbols* are an arbitrary relationship, agreed upon culturally or formally, that must be learnt. Traffic signals, letters, numbers and Morse code are all examples of symbols. *Icons* resemble or imitate what they are representing. This could include portraits, sounds effects or cartoons. Finally, *indices* indicate their meaning by what they are attached to. The connection is not arbitrary, but can be inferred by some physical or causal link. Examples of this include footprints, recordings and clocks.

Using this theory, contextual locations can be recast as a form of index. Each location means more than is immediately obvious – therefore each location is a *sign* in some way. These signs are connected to a variety of time, ownership and awareness information. These links between location (the sign) and context (the meaning) are formed and

understood because of the knowledge household members have of their routines and pathways through the home. Thus each location is an *index* into the routines and the context of the information.

4.4 Confirming and Extending Related Work

The findings of our study confirm and extend what others have seen. The most relevant related work is by Crabtree et al. [Crabtree, 2003b; Crabtree, 2004], whose publications motivated us to find out more about the value of locations in the home. Our approach and Crabtree et al's differed. We used contextual interviews as opposed to participant logs; we studied different household types, and we were working with North American families rather than British ones. In spite of these methodological and participant differences, we found that the concept of contextual location we observed in our households goes hand in hand with the three activity places described by Crabtree et al. Our idea of ownership and how it is exploited extends their idea of Coordinate Displays, i.e., places where information is left for others. Our idea of constellations are particular ways that their Ecological Habitats (places where information lives) are formed and used. Their notion of Activity Centres (places where information is created or worked with) are another way of describing the act of manipulating information within these locations. All are enhanced by our explanation of why people choose to leave things in certain places. Thus, part of our work confirms their findings. This confirmation is valuable to practitioners as it validates and adds richness to Crabtree et al's results and generalizes the work to a broader audience.

However, we stress that we have built upon Crabtree et al's previous work in three significant ways. First, we identified the types of communication information present in the home, i.e., reminders and alerts, awareness and scheduling, notices, visual displays, and resource coordination. While they show instances of these in their examples, we classify them as generalizable categories that developers can design for.

Second, we described how these places are initially selected by the household (constellations, pathways and routines), and how they are distributed through the home not

only in space but in time. This is important as designers can now not only determine what types of places should contain ubiquitous computing technology, but also where these places could be located within the home.

Finally, Crabtree's notion of space being interwoven with action [Crabtree, 2003b; Crabtree, 2004; Rodden, 2004] is extended by contextual locations to describe space as being interwoven with not only action and activity, but also with time, ownership and awareness. Our work looks to explain why inhabitants would select one Coordinate Display (for instance) over another Coordinate Display, and what these choices mean. This provides a more complete picture of the management of communication information in the home.

We have also confirmed and added richness and nuance to other related work concerning the specific ways such locations help us. Hindus et al. [2001] and Harper et al. [2001] described how the presence or absence of articles in specific locations, (e.g., a bill to be paid) is used by family members to monitor and help each other complete the tasks needed to keep the household running smoothly. Taylor and Swan [2005] investigated organizational systems in the home, and saw that the locations of informational artifacts could act as a trigger for conversation or serve as a physical point of reference for planning. We expand those ideas, looking at what these different locations can mean to household members, along with how they are established [Taylor, 2004; Taylor, 2005]. The common theme in these works is that people's understanding of routines, pathways and the social organization of their homes lead them to place information in varying locations around the home, and that these locations therefore have value to them and are a key part of information use in the home.

4.5 Practitioner Implications and Design Opportunities

Our work is intended to provide a more complete view of home communication information management than has previously been reported. Our study found that communication in the home involves a rich and highly nuanced use of information, routines, and locations. Our findings have implications for the design of ubiquitous or

context-aware technologies for augmenting communication and coordination in the home, and for practitioners who want to better understand the home environment.

4.5.1 Existing Communication Technology

First of all, our results point towards problems or weaknesses in existing technologies. While we did see many instances of electronic communication being used in the home, and these were included in our study, they were almost always supplemented by some sort of paper media – a sticky note reminding someone to read an email or respond to a phone message, a printed schedule from a web page etc. Electronic media currently cannot be situated in the home in the same way as paper media, and thus do not have the same value to household members.

For example, although email has many advantages over regular paper-mail, it has trouble replacing it because it does not provide the same physical affordances seen in our examples [Harper, 2001]. Other current communication technologies, such as electronic messaging, file and reminder systems also do not currently have the location affordances needed to fully replace physical ones. For example, while there are many commercial reminder programs available and in use, they do not include the location meta-data that home users need, and thus are poor replacements for (say) the scribbled note left with car keys or atop shoes. Filing systems on personal computers are impoverished as locations. A person may file something in a folder, and then quickly forget where it is. And since a person cannot flick through digital files to look for a picture on a handout she remembers, or know that it is in the stack near the coffee maker, it is hard to quickly re-find it. In addition, because of its history as an office machine, the PC is not currently well designed for domestic use, and is usually placed in an area that is isolated from the family's main activity centres [Mateas, 1996].

Of course, electronic systems can contain the same raw information, and provide many advantages over paper based systems: distribution over a network, searching and sorting capabilities, etc. Yet none have the meta-data we saw in contextual locations readily available. There is no way of attaching urgency, relevance or awareness information to

these types of electronic messages. Exploiting ownership is difficult, as ownership boundaries are rigid and access is often limited by passwords. This loses the richness of visible locations, be they personal or shared, as well as the ability to monitor other household acts for awareness. Thus the benefits gained by integrating existing technology into home communication are currently tempered or minimized by their inability to use or replace the physical affordances of locations.

4.5.2 Design and Research Opportunities

Given the richness of existing practices of communication within the home, design of appropriate technologies appears daunting. For example, it is hard to imagine technology that can replace the richness and flexibility of the sticky note, with its ability to be conveniently placed at any location. Yet opportunities abound. The types of communication information we identified can help designers target areas where the most value can be received from new systems, and what kinds of information these new systems could integrate.

Knowing the value of locations will provide designers with new uses and goals for current technology. For example, a movable projector system as described in Intille et al. [2002], could be used to display electronic messages in location-appropriate places. This kind of system would allow designers to go beyond physical world functionality, for instance by adding in the ability to place messages appropriately in particular home locations from work. It could even be an extension of a current instant messaging application. Another possibility includes the integration of displays and sensors into already meaningful home locations, so that electronic messages could be automatically displayed in appropriate locations. Messages could even migrate if, for instance, a person for whom there is an urgent message is sensed near a different display than the one initially chosen for the message. These ‘smart’ messages thus know about contextual locations and exploit routines and understandings already in place.

4.6 Summary

In summary, people's understanding of routines, pathways and the social organization of their homes lead them to place information in varying locations around the home. These *contextual locations* therefore have value to them and are a key part of information use in the home. They provide the information within them with *time, ownership* and *awareness* meta-data, including urgency, dynamics, status, responsibility, required actions, monitoring and support. This meta-data allows people to manage and filter the communication information in their homes.

This understanding of information management in the home is valuable to designers and practitioners in that it extends and adds nuance to existing research. This is turn helps to understand why technology such as email, calendaring and reminder systems fails to support these activities in the domestic environment. It also provides direction for extending these systems for use in the home, and for creating new designs that would support these information management activities in the home. In the following chapters I will present two design case studies. These case studies use the observations and results from Chapters 3 and 4, along with the related work from Chapter 2, to motivate and reflect on *location-based designs.*

Chapter 5. Location-Based Messaging

In this chapter[3] and in Chapter 6, I will use the observations and findings discussed in Chapters 3 and 4, along with the related work presented in Chapter 2, to motivate and create two *location-based design* examples. In particular, we created two prototype home designs. Each one uses contextual locations in a different way – the first to both define the problem and to create a solution, and the second to extend an existing solution to make it more useful. We present these, one here and the second in Chapter 6, as case studies that illustrate how our results can be used in future home technology design.

5.1 Location-Based Messaging

One way in which study findings can be used is to articulate problems that might be addressed with technology. In Chapter 3, I discussed how the most common information media used in the home was the sticky note. In fact, we saw that a considerable amount of information in the home takes the form of short notes scribbled on sticky notes or papers, e.g. reminders of things to do or remember, phone messages, requests, short notes about where someone has gone or when they will be home, a scribbled web link for the latest online hockey schedule, etc. These notes are often temporary; once they have been read and dealt with they are usually thrown away.

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[3] A version of the contents presented in Chapters 5 and 6 is available as a technical report.

Elliot, K., Neustaedter, C. and Greenberg, S. (2006) **Sticky Spots and Flower Pots: Two Case Studies in Location-Based Home Technology Design.** Report 2006-830-23, Department of Computer Science, University of Calgary, Calgary, Alberta, Canada, T2N 1N4. April.

Figure 5.1 shows several examples of these types of messages from study participant households. What is typical – and critical – in these examples is that messages are left in a wide assortment of meaningful locations, including tables, computer monitors, cupboard doors, the fridge, by the phone and even on other pieces of information like the family calendar. The important thing is that there *are* a variety of locations and that each is specific to the household's routine.

As an example of how this messaging currently works in the home, meet Anne, a working mother, who needs her teenage son Dave to put the casserole she has made into the oven. She needs him to do this as soon as he gets home from school, so that they can eat dinner before his evening band practice. She knows he's going to forget, so she writes him a note. She needs him to see the note right when he gets home, so she sticks it to the TV screen (as in the top left image of Figure 5.1). He won't miss it there because she knows the

Figure 5.1 Short messages are left in a variety of locations in the home

first thing he does when he gets home from school is play video games. Her knowledge of his routines helps her know where to put the message so that he'll see it in the right *context* – time and place.

Messaging is also one of the most popular computing applications, both outside the home and within it. Examples include instant messaging (IM), emails, SMS text messages, etc. These electronic messages can include rich content like web addresses, emoticons, pictures and other multimedia. Many study participants mentioned using these kinds of systems in their homes. They would email themselves reminders, or send each other links to pictures or websites. Instant messages and mobile text messages were often used for awareness information such as where other people were or when they'd be home. In two households where there were multiple computers, roommates or siblings would even IM each other from different rooms within the house.

These observations suggest that one area in home communication information that might be easily augmented by technology design is messaging. Since it is already a common activity, and already something computers do well, looking at how to design a digital messaging system specifically for the home is a natural choice for domestic technology design.

The understanding gained from contextual locations can also be used to suggest the direction of the design solution. As described in Chapter 4, we saw that the location of messages in the home is chosen by household members to give the message valuable time, ownership and awareness context. The message is more valuable because of *where* it is. Household members know how urgent a message is, who it is for and even what needs to be done with it by where it is placed or seen. Even in the households that used electronic messaging (using systems like MSN Messenger, or Yahoo!), these were never a replacement for the scribbled paper note, because participants couldn't put these electronic messages in any home location other than wherever their computer was – usually a home office or bedroom isolated from the rest of the house. For instance, in our Anne and Dave example, if Anne had emailed or IM'ed her son that note, he would not have seen it until much later, and the casserole wouldn't have been ready on time, because checking his

email isn't part of his after school routine. A home messaging design solution should therefore be *location-based* if it is to be successful.

5.2 StickySpots

Figure 5.2 shows a screenshot from StickySpots – the *location-based messaging* system I have developed. StickySpots is designed to send messages primarily to specific locations in the home, where messages are shown on a network of displays incorporated into specific locations with the domestic environment. These displays would include existing TVs and personal computer monitors, along with new displays that would be integrated into the home, such as the new Ultra-Mobile PCs recently announced by Microsoft. While such a network of displays is currently cost-prohibitive, it is reasonable to imagine that future smart homes would have many networked displays – even touch sensitive ones – in a wide variety of locations. In StickySpots, each display in the home is signed in to a central

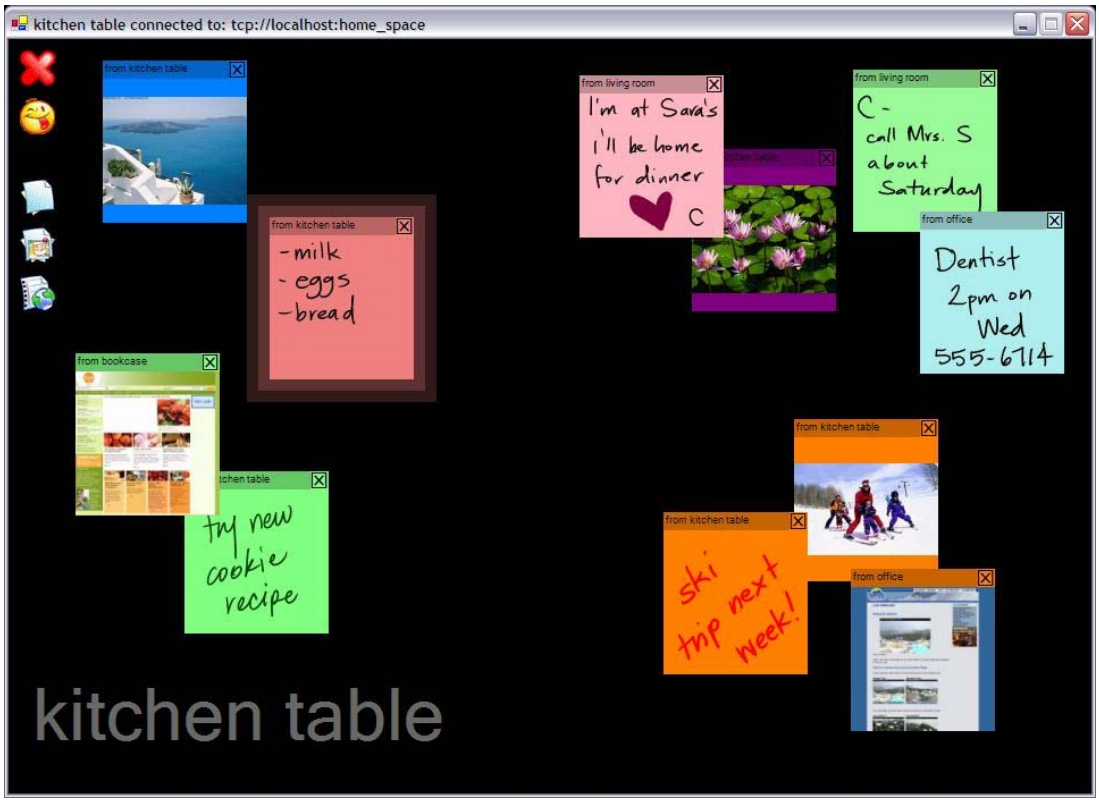

Figure 5.2 StickySpots – location-based messaging

server, so the messages can be sent to any of these displays from any other one. With the displays placed in locations important to the household as message centres, this becomes *location-based messaging*.

5.2.1 System Description

StickySpots is designed to look like a bulletin board. It allows household members to create and colour simple handwritten notes (Figure 5.3a and b), reflecting the manner in which people already leave messages (via pen and paper). We also use ink input for practical reasons: it can be cumbersome to situate keyboards and mice throughout the home. Previous studies [Hindus, 2001] have also shown that electronic handwritten notes are very effective in homes. These handwritten messages appear as small coloured "sticky notes", like those in Figure 5.3.

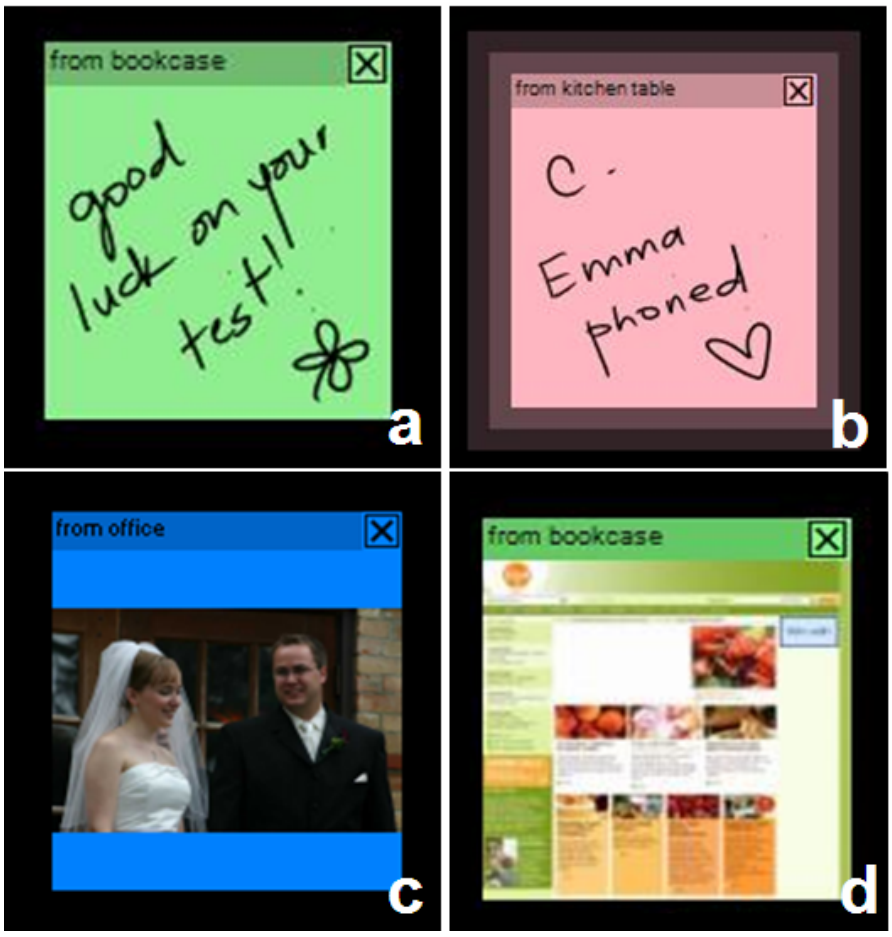

Figure 5.3 Notes sent with StickySpots, a prototype location-based messaging system

Messages can be sent to locations in two different ways. First, one can send it to an actual location, e.g. the living room TV. Senders create a new note, select a destination, and the note appears on the receiving display. The colour of a note is chosen by the sender, and thus can be used to communicate anything the household chose – for instance a bright colour for urgent notes or a certain colour for each person. New notes have a soft halo to indicate their status (Figure 5.3b) so household members can easily see changes.

Notes appear in a random arrangement on the display, but people can move them around as desired, e.g. into piles. Touching the note shows when it was sent and where from. Notes are opened to a larger size by double tapping, and replies are easily added and sent. Web links and small images can be included within a note, as in Figures 5.3c (photo) and 5.3d (web link). Double tapping on a web note opens the link in a browser window.

The second way that messages can be sent to a location is to send them to a person as a sort of location proxy. These messages then appear on any display close to that person. The display identifies people through either having them sign in explicitly through a simple dialog, or by sensing their presence via jewellery-based RFID tags. Figure 5.4 shows an example of this later case. An RFID tag is attached to the back of a wristwatch, and each display contains an RFID reader. As a person is detected, the display creates a small grey side pane on its right side (bottom of Figure 5.4) labelled with that person's name, and shows that person's messages within it. This allows messages to be sent to wherever the person is, without the sender needing to predict where they are or will be, or to wait for the recipient to go to a specific location.

Because StickySpots is networked, it is also possible to send messages to locations from outside the home, such as when at work or while traveling. This is a major benefit of technology; people temporarily outside the home can now use their natural understanding on household routines to place the note in the right contextual location. It is also possible to sign in to a location remotely – for example, to see the messages in the kitchen from your office. This allows people to remotely "look" at the information in their home.

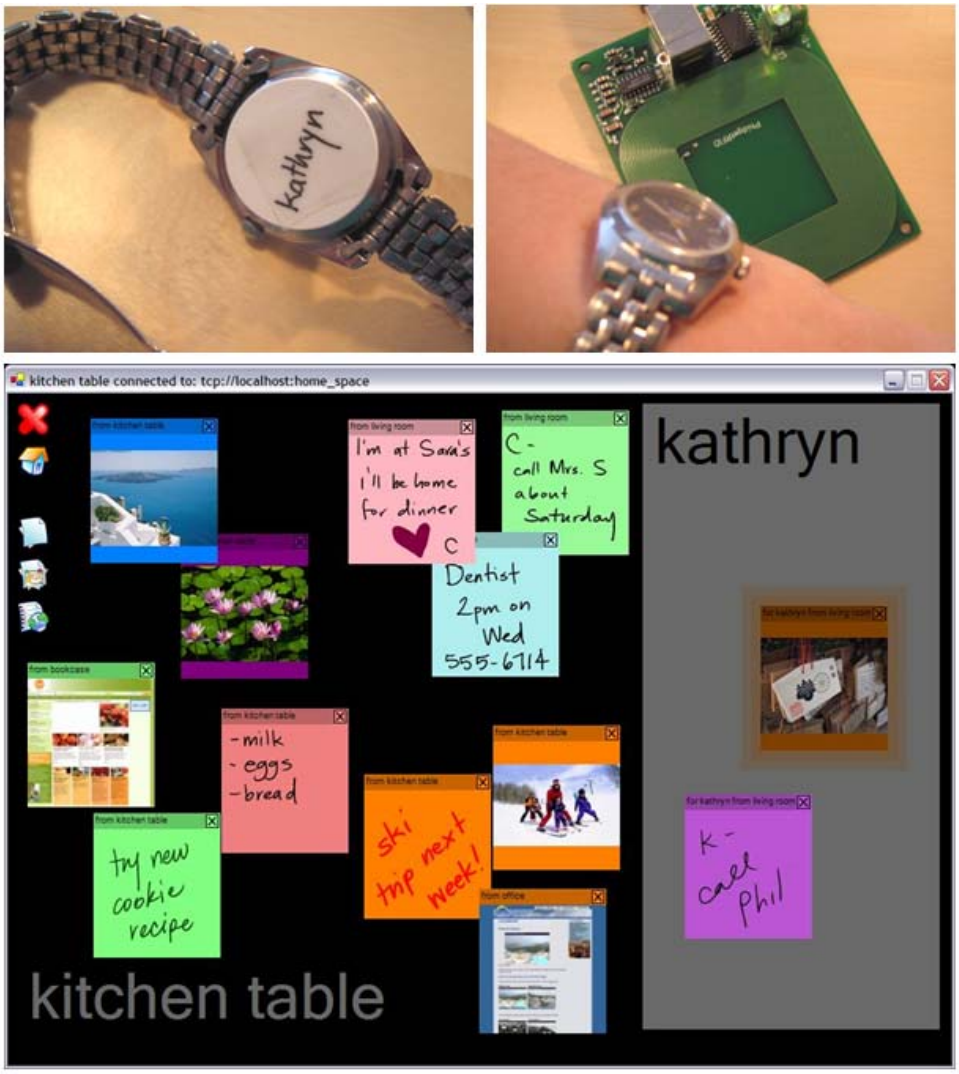

Figure 5.4 RFID tags, small enough to be worn, identify people and show personal notes

5.2.2 Implementation

StickySpots was built using three prototyping toolkits. GroupLab.Networking enables the easy creation of a server to share information between locations [Boyle, 2006]. The notes are delivered as multimedia photos using the Collabrary [Boyle, 2005], and the system uses Phidget RFID readers to identify people [Greenberg, 2001]. StickySpots is written in C#.

StickySpots uses a shared dictionary notification server to connect locations. Information is stored in the dictionary using a key/value pair, and downloaded from the dictionary when the appropriate key is notified.

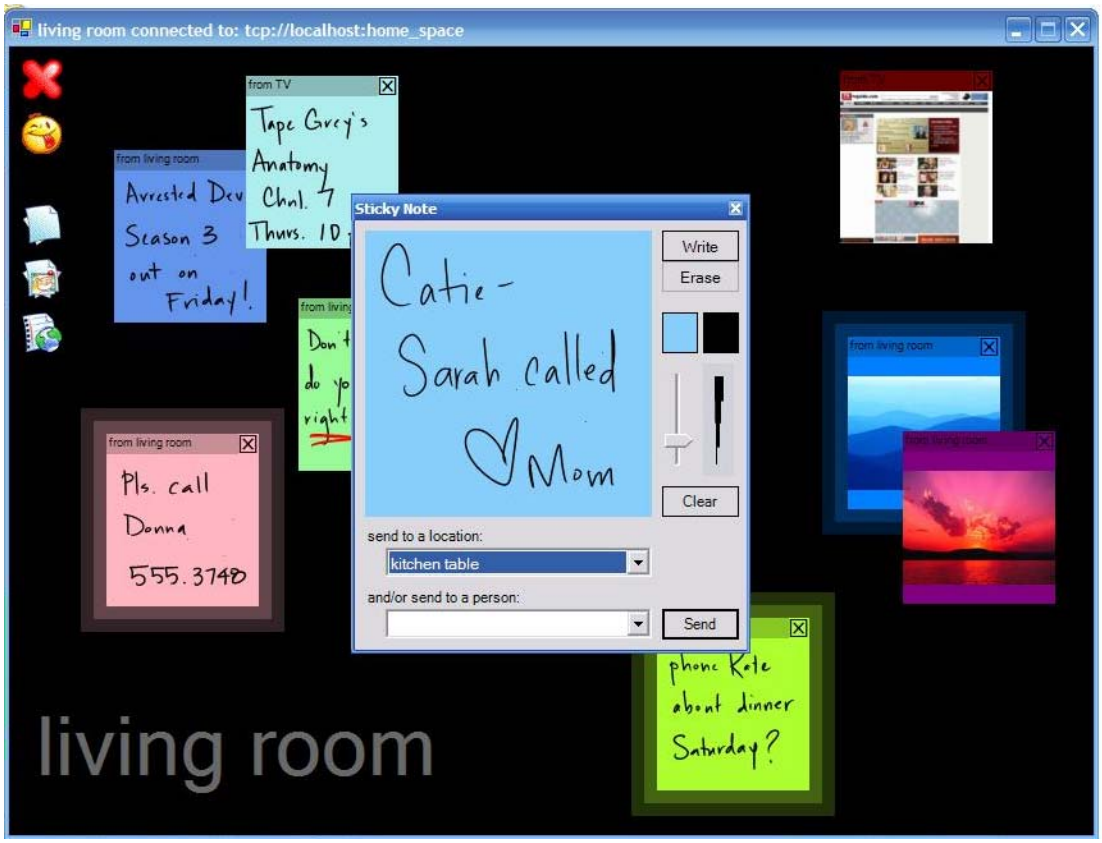

Figure 5.5 A sticky note being created with StickySpots.

The best way to illustrate this is by example. Anne, a mother, sends a note to her daughter Catie to let Catie know her friend Sarah called. Anne is in the living room when she answers the phone and takes the message. Anne would like Catie to see the message when she gets home from school, and knows that Catie usually gets a snack first thing, so she decides to send the message to the kitchen. Figure 5.5 shows the note that Anne creates for Catie.

When Anne hits send, the message is sent from the local system in the living room to the shared dictionary, stored as a series of key/value pairs. All the pairs for a single message have the same unique identifier in the key so that all the information relating to that message can be grouped. Although simplified for the purposes of this example, the keys for Anne's message to Catie would include:

```
/message/0001/from_location = “living room”
/message/0001/to_location = “kitchen”
/message/0001/ink = [ink annotation value]
/message/0001/time_date = “2:45pm, 28 August 2006”
```

Each instance of StickySpots subscribes to the message key, and thus to all keys beneath it. When a new message is posted, all instances receive a notification on that key. They then check the value of the “to_location” key to see if the message is theirs. If it is, that instance (in this case the kitchen) creates a new note to display and downloads the values for that note, including the ink content and the sender information, from the shared dictionary. The note is randomly placed on the receiver’s display, with a halo to indicate that it is new (as in Figure 5.6). For more details on the architecture of StickySpots, please see Appendix B.

Once Catie sees the note, she deletes it. At that point the corresponding key/value

Figure 5.6 The new sticky note (circled) as it is displayed at the receiver.

pairs are removed from the shared dictionary. Web and image stickies work the same way, except they have extra key/value pairs to contain the compressed image or screenshot, as well as the URL. Personal stickies also work the same way.

5.3 Discussion

While valuable as an invention, we don't claim that StickySpots is an ideal solution, or even (for now) a practical one. Its main importance is that we can now use it to reflect and critique it as a design.

5.3.1 Adding Value

Returning to our earlier scenario, we can see how StickySpots adds value. Anne has just finished making a casserole for dinner the next day. She puts the casserole in the fridge, and – while still in the kitchen – uses StickySpots (running on the fridge's built in display) to write a note to Dave. She selects the location where she knows her son will see the note when he comes home – the TV – and sends it. The note then appears on the TV as a small coloured "sticky note", like those in Figure 5.3. Anne simultaneously sends the note specifically to Dave, so that on the off chance that Dave decides to do homework instead of play video games when he gets home, the display in his bedroom will sense him and the message will show up there. Unlike email, which he may read at school and forget, or not check at home until too late, Dave will see the note at the right time (when he arrives) and in the right context (in the home), and remember to put the casserole in the oven.

StickySpots adds value in that messages can be sent from anywhere: Anne can send it right from the kitchen as she's cooking or even from the office the next day. It also allows for more flexible messaging choices: she can send to a specific location, or send the note to Dave and have the system sense his location. In addition, messages can be media rich. Anne's message could contain a link to the casserole's recipe online so Dave can see the time and temperature details, and even a picture of what the finished product should look like.

5.3.2 Related Work

Other domestic messaging systems include HomeNote from MSR Cambridge [Sellen, 2006] first discussed in Chapter 2. HomeNote lets people send a text message from their mobile phones to a single display set up in a public area of their home. Household members and guests can also scribble handwritten messages on the display. Though not targeted specifically for the home, Place-Its [Sohn, 2005] allows users to set text reminders on a GPS enabled mobile phone, so that they will be triggered when they go to certain places, such as work, home or the store.

While both these examples are location-based messaging in some sense, and definitely have value, they use location in a larger, macro way – treating the home as containing a single location unit (wherever the household locates the display or wherever the reminder is triggered by GPS). Our knowledge of contextual locations suggests that there is even greater value in having messages sent to *many specific locations within homes*. Messages within the home use location in a more micro or specific sense, e.g. the kitchen table, the mat by the front door, etc. so that the home contains multiple location units. It is these specific locations that provide the contextual time, ownership and awareness information that people choose from their knowledge of domestic routines. This different way of thinking about location is exploited by StickySpots, and this is what differentiates it from HomeNote and Place-Its. Our design insight is that *technology should use these micro locations* rather than thinking of the home as a single place, if it is to enhance what people currently do.

5.3.3 Reflection

StickySpots is not intended to, nor can it, replace existing home messaging techniques. Rather, we see it as complimenting them. For example, a display-based StickySpots does not address all the nuances of how households use locations for messages. Households use not only location contexts, but also physical contexts – attaching notes to existing but meaningful piles, items or surfaces. StickySpots does not currently exploit this physicality.

However, we could easily extend StickySpots to provide even more value. One possibility is to have small, cheap mobile displays that can be attached to objects, i.e., a truly electronic version of a sticky note, incorporating some of the physicality mentioned above. StickySpot notes could be sent to these small displays. While this means that a person must be present to attach the note to the object, its content could include dynamic information, and could be edited and added to from a distance. Other potential extensions include allowing rich text or audio stickies along with handwritten ones, and providing support for sending messages to and from mobile devices, such as phones and PDAs. Knowing that physical notes also exploit time, we could add the ability for users to create *timed reminders* that would appear at the selected location at some specific preset time. Because notes are used for awareness, *automated messages* could also be sent to a preset location when a web page or other information is updated. We also believe future homes will contain a wide variety of information display types. Thus StickySpots could be extended to send messages to other kinds of displays: small text LCDs, physical appliances, and audio displays.

Location-based messaging is only one example of how we can use contextual locations to articulate areas in home information management that could benefit from technology. For example, *reminders* are somewhat similar to our messaging example in that there are already commercially available systems that provide reminders and task lists, often as a part of calendaring programs (e.g. see Microsoft Outlook). However, these systems are not well suited for the home because they require the user to be sitting in front of the computer to receive the reminder. Reminders in the home are spread out over many locations so that they will be seen at the right time and in the right context. GateReminder [Kim, 2004b], first discussed in Chapter 2, is a prototype system that lets reminders be sent to the home's entranceway, and then displays them as people enter or leave – a good extension on how people leave DVDs or other items at the door so they don't forget them. Extending this system to other locations in the home, perhaps by incorporating it with something like StickySpots would be one way to apply location-based design. Another way to do this would be to allow calendar reminders to be sent to StickySpots. When setting a

reminder on your calendar, people would not only specify a time, but also a location where the reminder should appear.

Of course, we realize that these reflections may not be born out in practice. The design of StickySpots and similar systems may fail for reasons that have nothing to do with our belief in location-based messaging (e.g., interface issues or display issues). Alternatively, households may (or may not) bring StickySpots into their lives in unanticipated ways. This does not negate the value of reflective practice. Reflection such as reported in this chapter is a way to consider designs and their uses *before* deployment. The idea is to focus and critique the major design features and their effects, and to anticipate uses and misuses before they happen. As in conventional interface design, systems such as StickySpots still have to go through an iterative design/evaluate/redesign process to capture and repair both low-level and conceptual interface bugs.

StickySpots uses location as a means to both suggest a problem and to direct the solution. In the following chapter I will present a second design case study that uses location in a very different way.

Chapter 6. Location-Dependant Displays

In this chapter[4] I will present a second design case study that exploits the power of contextual locations in home communication systems. The first case study, StickySpots, used contextual locations to define a problem and to direct a solution. A second way we can exploit our improved understanding of information management in the home is to use it to extend existing technology to be of greater value or to be better integrated into the patterns of the household. In this chapter I will present a second design case study, FlowerPots, wherein I will discuss an existing ambient display and how it can be *repurposed by location* to provide additional value in the home.

6.1 Flexible Ambient Displays

We have an existing set of physical devices called *flexible ambient displays* which are designed to meet two specific design goals: to allow for flexible information sources and to provide a smooth transition from awareness into interaction [Elliot, 2004]. These two goals suggest that these displays could have value in a domestic environment.

6.1.1 Flexible Information Sources

The devices are 'flexible' displays because each device's capabilities can be mapped to different information sources easily, which separates the design of the device from the

[4] A version of the contents presented in Chapters 5 and 6 is available as a technical report.
Elliot, K., Neustaedter, C. and Greenberg, S. (2006) **Sticky Spots and Flower Pots: Two Case Studies in Location-Based Home Technology Design.** Report 2006-830-23, Department of Computer Science, University of Calgary, Calgary, Alberta, Canada, T2N 1N4. April.

selection of an information source. Each device's functionality is exposed to the programmer as a standard object API, so while they do require coding knowledge to build new applications, these programs are relatively easy to create. Therefore, these displays could be used to show some of the information household members are interested in, even though this information would be very different from household to household.

6.1.2 Awareness into Interaction

These displays are designed as physical ambient displays, so they are intended to show information in the periphery of the users' attention. We feel that displays such as these could be very useful in the home. Because they are ambient displays, they will not contribute to information overload. Their physical nature means that they can fit more naturally into the domestic environment – previous work has shown that the home itself is a display, and that people decorate and personalize their homes with things that have meaning to them as a way of imprinting their identities [Hindus, 2001]. Therefore, a display that shows information valuable to them, and is attractive, should be a welcome addition.

The displays also allow for user interaction. Each contains a simple touch sensor, so simply touching the device can request more detail, smoothly moving the user from awareness of the information into interaction with it. Thus, they allow more detail and interaction with the information in the place where it is displayed, which is especially valuable in the home, where people are not sitting in front of a computer all day.

Figure 6.1 The FlowerPots device

While several flexible ambient displays have been built, we will use one as an example here: FlowerPots [Elliot, 2004], pictured in Figure 6.1.

Built using Phidgets [Greenberg, 2001] it is a small box containing felt flowers with red or green lights in the centres, with a touch sensor under the front flower. Its display of on/off/flashing lights serves as an abstract *vs*. literal display of information.

6.2 Location-Dependant Information Appliances

Since flexible ambient displays are designed to show a wide variety of information sources, one way we could use location is to decide what information is to be displayed. The premise is that household members are interested in different information as they move to different contextual locations over the course of the day, i.e., particular information appears in those places as they move through their daily routines. If we allow our displays to be easily moved, they can be repurposed automatically, i.e., we can automatically display (different) information relevant to that contextual location on the relocated appliance. Information then benefits from the valuable, even indispensable, context provided by that location.

For example, a display in the bedroom may indicate weather conditions. If that display is then moved to the home office, it may show the IM status of a contact one wishes to reach. If moved next to a desk containing a bill pile, it may indicate that some are overdue and thus should be dealt with immediately to avoid interest charges.

6.2.1 System Description and Implementation

We extended our FlowerPots into a *location-dependant information appliance*. We added a Phidget RFID reader (Greenberg and Fitchett, 2001) to the device, and placed small, easily concealed RFID tags in various places in the home. We created a simple management program to assign location tags to applications that display information on the flexible ambient display. Thus a location becomes virtually connected to information. Currently, FlowerPots is connected to a tablet PC (for prototyping) so it can be easily moved, though in a final design all computing elements would be self-contained.

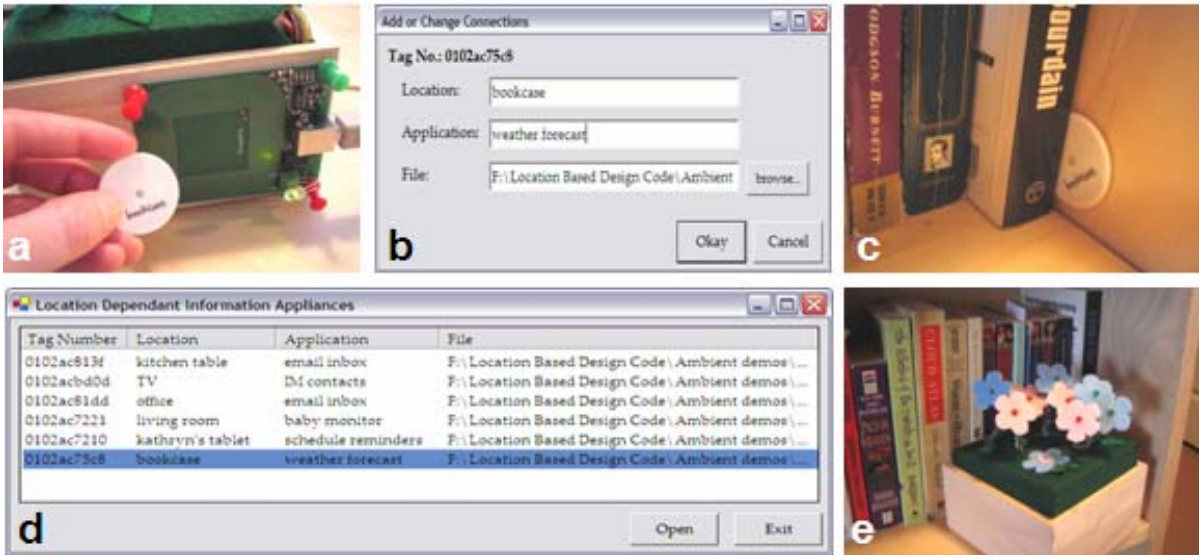

Figure 6.2 Assigning a tag to an application, and then placing it in a location

The assignment of tags to locations and to display applications is very straight forward, as shown in Figure 6.2. When the new tag is shown to the device's RFID reader (as in Figure 6.2a), it is recognized as unknown. The person can then name the location, describe the information to be displayed, and select the application to run in that location (Figure 6.2b). The person then conceals the tag in the desired location (Figure 6.2c). When that tag is now read by the ambient device, the management program starts up the particular information delivery application assigned to that location.

The applications are completely separate from the management program, so it is easy to add a new one, or to change existing ones. These assignments are saved to a file, so there can be several configurations set up for a household or device (say for different people within the home, or for different days or times of year).

The fact that the devices contain touch sensors mean that more detail is available through a simple gesture. This works with Crabtree and Rodden's [2004] understanding of place being interwoven with action and activities since the space is now not only used as an contextual place for information display, but also as a way for people to interact with the information *in place*. This permits the information *and* the interaction to be a part of everyday domestic routines.

For example, when placed in the bedroom, FlowerPots may invoke an application that maps good and bad weather reports as steady or increasingly flashing lights, with a touch invoking a full audio-based weather report. When moved to the home office, it changes the application to one that shows the away, busy or online status of an IM contact by the number of lights lit, where a touch plays back the last dialog.

6.3 Discussion

As with StickySpots, we don't claim that FlowerPots is an ideal solution. It is however, useful as an example of how contextual locations can be used to repurpose or extend an existing system to be more valuable in the home.

6.3.1 Adding Value

Imagine a busy family of four. They have several locations within their home tagged: the phone desk, next to where they keep the family calendar; a placemat on the kitchen table; the front entranceway; and the living room mantle. When on the desk, FlowerPots glows to show when there have been updates to the online versions of the kids' sport schedules – touching it reads off the changes so they can be copied to the calendar. The family moves the display to Dad's placemat at the kitchen table when he is traveling for work. There, it lights up when Dad sends the family an email or a recorded audio message. Touching it reads the message aloud. When the family gets especially busy, FlowerPots is moved to the front door, where it flashes with reminders sent by Mom for the kids about what they need to take to various activities. Finally, FlowerPots is sometimes placed on the mantle next to a picture of Grandma, where it shows her activity level, so that the family knows she's doing well. In this way, FlowerPots becomes more valuable in the domestic setting when it is *location-dependant,* and fits into the family's natural routines and pathways through the home. While the device is continually repurposed, it is easy to tell what information is currently displayed because it is shown in the contextual location of the household's daily routines that helps that information make sense.

6.3.2 Reflection

Would people *actually* move these flexible ambient displays to different locations? There is certainly a possibility that they would, especially given the unique richness that the varying locations bring to the ambient display. Existing household artifacts such as papers and notes, CD players and laptops, calendars etc. do get moved throughout the home because of their use in different locations; we argue that ambient displays could provide even more location richness. However, the alternative scenario where devices stay in a given location is very possible. We feel the ambient displays would still have value even in this situation for they can provide simple and understandable location-based information representation and interaction in a tangible device.

An extension that could add further value and address the above possibility, is the ability to not only change the information displayed by *location*, but also by *time* - households are interested in different information in different places, and also in different information at different times. Currently, time is used implicitly; i.e., repurposing by location occurs *when* a person moves the display, but this could be extended to allow people to explicitly set time-based changes. The design could also be extended to use *ownership* in a similar manner. Different people are interested in different information in the same location. The device could use personal RFID tags, similar to how StickySpots does, to change the information shown depending on who is around or interested.

A challenge with FlowerPots is that when we look at extending it to be repurposed by location, time and ownership it may become hard to tell what information source the device is displaying, since the display is so abstract. One way to address this would be to add an indicator, such as a text LCD display or several labelled lights, to allow users to easily see what the current information source is. Touching the device could also provide this feedback aurally.

FlowerPots is just an example; many other physical displays could be built and repurposed in the same way. The picture frame, for instance, is a frequent choice for ambient or home information because it is such a common and meaningful household

artifact [Mynatt, 2001; Chang, 2001]. A picture frame could be connected to a remote family member when placed on the mantle, but show family calendaring information in the kitchen. Lamps and other lights are also popular [Ambient™, 2006; Tollmar, 2002] and could again be repurposed as information displays by location. A lamp could be used as a reading light when placed on a desk, and as a gentle information display when on a shelf.

Other more generic displays could also change the information displayed depending on where they are placed. A tablet PC placed by the home entrance could run a reminder system. When moved to the kitchen, it could display a family calendaring program. We could also combine our flexible physical appliances with more conventional displays to create applications that work in tandem. For instance, FlowerPots could be used to "extend" a location from StickySpots. FlowerPots could show the number of new messages in the extended location, and could provide message details when touched. By allowing a location to be extended, we provide value beyond what is normally available. Imagine deciding to work in the kitchen instead of in your home office because you need more space, but still being able to receive the messages that would normally be sent to you in the context of work – context is thus extended with location.

Like the flexible ambient display project, other existing research projects could be extended or repurposed to take advantage of contextual locations. The Everywhere Displays movable projector [Pinhanez, 2001] could be combined with instant messaging or email to create a location-based messaging or reminder system similar in goal to StickySpots. HomeNote [Sellen, 2006] could be extended to multiple connected displays to combine their person-to-place messaging with place-to-place messaging within the home.

As with StickySpots, we realise that these anticipated uses may not reflect how the system is used in reality. Households may or may not move the FlowerPot device from place to place within their homes, or they may move it with widely differing frequencies. Different households may develop drastically different usage patterns. As the device is designed to be flexible, different households may choose very different information sources, or they may change information sources many times. There may be other, completely unanticipated uses or effects. Therefore, like StickySpots, FlowerPots will need

to go through a process of evaluation and redesign several times. The reflection provided here is intended to simply begin the design process.

6.4 Design Guidelines

The PC, a system designed for the office, has failings in the home that become more understandable when examined in the context of locations. It is usually in an isolated place in the home, so it is something that people have to go and check explicitly, as opposed to a place they see as part of their pathway through the home. Ownership boundaries are too rigid with passwords and single user accounts, so there is no way to make information public or for family members to maintain awareness of each other. All the information within the PC is in one place physically, so there is no way for people to attach any kind of context to it. These issues are not easy to solve, but they are important, and should be addressed by future home systems.

To help consider how this can be done, we have created a "prototype" set of design guidelines based on home studies and our own experiences from design case studies. These guidelines serve as a starting point for developing location-based design heuristics. These may prove useful for both guiding and evaluating design.

1. ***Use Context: Location-based designs should use the power of context.*** These designs should value and use their placement within the home as a tool to enhance information – a spatial means of providing the information they display with context, increased value, and interaction opportunities. [Crabtree, 2004]. They should exploit the fact that location will provide contextual time (urgency, status and relevance), ownership (personal, public, privacy level) and awareness (monitoring, presence/absence) information

2. ***Add Value: Location-based designs should add virtual value to existing household spaces and organizational systems.*** Rather than replacing what households currently do, location-based designs should complement and enhance existing methods. They should provide more power when compared to paper or other traditional workarounds,

e.g., adding search, sort or networking capabilities; providing dynamically updating information, adding multimedia, or integrating further interaction opportunities. Designs should do this without requiring one to return to the PC, so that the extra value is available as a natural part of the household ecology.

3. ***Be Specific: Location-based designs should use location in a micro rather than a macro sense.*** Designs should consider specific locations and their contextual meanings, e.g. the kitchen table, the mantle, the front door, etc. rather than simply the encompassing macro of 'home'. This is how household members already think about information placement in their homes.

4. ***Be Flexible: Location-based designs should be flexible and able to integrate into the existing routines and patterns of the household.*** Designs should not force changes to routines. They should allow for household individuality – they need to fit within existing systems while still providing extended value and opportunities. A flexible system should allow for change, as households rearrange, grow and evolve. This flexibility is an important part of enabling new kinds of technology in the home [Edwards, 2001; Hindus, 1999] as it enables people to fit the technology into their existing household systems without requiring either an entirely new house or extensive renovations or upgrades.

I will now revisit my two case studies from the perspective of these guidelines.

6.4.1 StickySpots

StickySpots uses all these guidelines. It **uses context** in that it is intended to be located in many locations around the home, and allows people to use their natural understanding of the routines of those they live with to decide where to send a message so that it is in the right context. StickySpots **adds virtual value** above and beyond paper messages primarily by allowing the person creating the note to not actually be in the location the note is delivered to, and by sensing people in order to deliver messages to them no matter where they are. It also provides value by adding links and pictures, as well as time and sender information. StickySpots uses location in a **specific** micro sense, rather than considering the

home as a single unit, which is crucial to how people see messages. StickySpots is **flexible** in that household members can choose the locations and name them in any way that makes sense to them. They can also add and remove locations very easily, as they add new displays, rearrange current displays, or change how they use the system. While we do believe that like any technology, its introduction will produce some changes in household routines, it does not force these changes as it is designed to fit into the existing patterns. One flexibility weakness of StickySpots is that most households do not currently have the network of displays that is needed for it to be effective; however we do believe that the future smart home will have this, so it is only a temporary issue.

6.4.2 FlowerPots

FlowerPots is an example of a *location-dependant information appliances.* It too reflects the design guidelines presented earlier. By repurposing the displays by location, we are **using the context** of those locations to make the information more valuable. These devices **add value** in two major ways. First, allowing digital information to be displayed on a physical object in any location means that people no longer have to go to their computer and actively look up the information – they can maintain an awareness in the periphery of their attention. Second, the touch sensors on the devices allow users to easily request more detail without losing context. These devices use many locations within the home, so they are using **specific**, micro locations. And finally, the devices are very **flexible** and easy to integrate into the existing home. All that is required is a wireless network, and these are increasingly common. Tags are easy to place in locations and to assign to programs. While the creation of new applications still requires programming knowledge, we can imagine that if these devices were made commercially available, new programs could be easily downloaded from a website, similar to the model used by Ambient's Orb (Ambient™, 2006). Our current device runs off a tablet PC, meaning that the tablet needs to be moved with the device, but again, it is easy to imagine that these would be self-contained in a commercial product.

6.5 Next Steps

I have previously alluded to the importance of iterative design for StickySpots and FlowerPots in terms of narrowing towards a successful system. In this thesis, I concentrated on the early portions of this design process: understanding current practices within households, applying this understanding to two quite different designs, and reflecting on its use in practice. The next steps for these projects include setting the two example systems up and evaluating them in real households. While routine for task-oriented productivity software [Dumas, 1999] this set-up and evaluation is a major challenge within domestic settings and expected uses. First of all, the infrastructure to support these kinds of technologies does not currently exist in homes. There are not, for example, pen- or touch-sensitive displays spread throughout the home on which we could easily run StickySpots. Deploying StickySpots to a home would involve also deploying this infrastructure. This infrastructure would not only have to be set-up specifically for the system, it would also need to be easily removed at the end of the study, since most people do not currently have use for displays spread throughout the home. For FlowerPots, deployment into a real home situation is slightly easier, but still involves a lengthy set-up period, while a wide range of source applications are discussed and developed for the study participants.

In addition to these practical problems, both of our case study systems are such that their real value becomes apparent only when they are socially adopted into the routines of the household. This social adoption, the incorporation of a new technological system into home life, happens slowly. Short studies run the risk of studying only the novelty effect of a new "gadget", rather than how it would actually be used in daily life. In addition, each household will use the systems very differently, so a wide range of participants must be found.

While these challenges can be overcome, it is not within the scope of this thesis to do so. Instead, I use these case studies only as examples of different ways in which contextual locations can be used to inspire design. The evaluation of these designs is left for future work.

6.6 Summary

In this chapter and in Chapter 5, I have presented two case studies of domestic technology design along with design guidelines as a means to illustrate how findings from studies about location use in everyday routines can be applied to the design of home technologies. While these case study systems are certainly first cut prototypes, they are important for they provide proof of concept systems to illustrate how one can move from domestic study to design. Study findings often provide very detailed and valuable information, yet these findings are not always the easiest to apply to design [Dourish, 2001b]. Thus, my main contribution in these two chapters is to show through simple and initial examples how one can design for home information and contextual locations. StickySpots, the location based messaging system, uses the observations from the study to define an area for technology application. It then uses contextual locations to suggest the design solution. Location dependant information appliances such as FlowerPots use contextual locations to extend an existing system to be of more value in the home. While both prototypes and the guidelines still need evaluation, they are good initial examples of how to apply location-based design in the home.

Chapter 7. Future Directions

This chapter summarises the contributions of this thesis. I will first reiterate my thesis problems from Chapter 1. I will then describe my research contributions, and discuss how they address each problem. Finally, I suggest future directions for communication information technology in the home.

7.1 Thesis Problems

In Chapter 1, I defined three research problems in the area of home communication information:

1. **We do not know what kinds of communication information are present in the home**. While we do know that communication and coordination information is plentiful in each home, we do not know whether there are different types of information, how common each type is, or how people use different kinds of messages. Knowing this is critical if we are to design effective home communication systems that gather appropriate information and display it at the correct moment and in the correct form.
2. **We do not know how household members organize and cope with the communication information in their homes**. Homes contain a vast amount of information. It is unclear what mechanisms people use to know which messages are relevant to them at particular times. We do not know how household members organize personal information or information for other members of their households. We do not know how each member decides what pieces of information they are or are not responsible for, or how this decision making process changes over time. Yet this information is needed if we are to design information displays and interaction metaphors that fit naturally into the home. This understanding and natural fit is vital in the home environment, as people are slower to accept technology in their homes [Venkatesh,

1996] and will be less tolerant of any system that is not easy to use or that does not fit smoothly into their domestic routines.

3. **We do not know how to design natural systems for the display and management of communication information in the home.** The home is a very different environment from the workplace. While there has been much research into designing information systems for the office, not as much work has been done in the home, where people's needs and desires for technology and goals for information management are less well understood. It is unclear how a system for managing information in the home should be designed in order to provide natural support for this very different type of information management.

7.2 Research Contributions

I have addressed these problems in this thesis, through three main research contributions:

1. **An identification of the five types of communication information in the home.** I presented an exploratory study intended to examine communication information in the home. We saw that many households had very large quantities of this type of information, especially those households with children. In Chapter 3, I discussed the five kinds of communication information that we saw in our participant homes, and presented these as generalised types. While many authors in the related work present examples of communication information in the home [e.g. Crabtree, 2003b; Harper, 2001; Tolmie, 2002], my thesis presents not only examples but general categories that can be identified and designed for. *(Problem 1)*

2. **An articulation of the concept of *contextual locations*: the vital role that location plays in the management and organisation of communication information in the homes.** As part of the study discussed in Chapter 3, I also investigated how people managed the communication information in their homes. As presented in Chapter 4, I found that the location of a piece of information provides household members with valuable meta-data about it that allows them to easily decide how to handle it. This

meta-data, related to *time, ownership* and *awareness*, allows people to quickly deal with the vast quantities of information present in their homes. Chapter 4 discusses how these *contextual locations* are chosen, distributed and selected over time, as part of the household's ecology. I also provide a secondary contribution by validating Crabtree et al.'s [2003b] assertion that information spaces within the home are interwoven with action and function. My work supports this and then furthers this idea by showing that these spaces are also interwoven with rich contextual information. Chapter 4 also includes a discussion of the implications that contextual locations have for the design of home technology, as well as how they help identify problems in how technology is currently applied in the home. This understanding of locations and context is the most major contribution of my thesis. *(Problem 2)*

3. **Two design case studies demonstrating how contextual locations can be applied in home technology design.** In Chapters 5 and 6, I present two example designs, and discuss how they use location in very different ways. In Chapter 5, I present the *StickySpots location-based messaging system.* When set up in a home, this system allows handwritten messages to be sent a variety of locations in the home, so that people can use the natural contextual information that they already understand. In Chapter 6, I discuss my second case study: *location-dependant information appliances.* In this case, I took an existing flexible ambient device, FlowerPots, and extended it using the understanding of locations discussed in Chapter 4. The device can change the information it is displaying depending on where it is placed in the home, thus taking advantage of the context provided and increasing its value in the home. This example shows another way in which existing technology can be extended to take advantage of locations in the home. In the same chapter I also presented my set of prototype design guidelines for location-based design. These guidelines still need to be evaluated and extended, but they are a starting point for the development of a set of location-based design heuristics. I then discussed the designs from Chapters 5 and 6 in terms of the design guidelines. While these design examples have yet to be formally evaluated, and the guidelines are prototypes, their importance, and my contribution, lies in their illustration of the applications of contextual locations. *(Problem 3)*

7.3 Future Work

It is now obvious that having all information available through some kind of monolithic computer application accessed through a conventional display – as happens with the traditional personal computer – misses all the nuances of location placement. While people have shown that they can get by, they lose all the richness of how information is spread around the home. Unless people are actively and more or less continuously looking at the screens of traditional computers they will not know what information applies to them or what they have to deal with at the moment, and they will not be reminded at appropriate times. Locations are used on such a large scale within the home that they cannot be ignored. It is key to how people deal with the ever-growing information pool they have available to them. Locations need to be valued not just as a place in which to work with or to display information, but also as a spatial means of providing it with context, value, and interaction opportunities. This means that if and when designers look at integrating technology systems into the home, they need to provide this meta-data either through physical locations, or through some kind of digital replacement. As home inhabitants add meaning when they select the locations over time, locations cannot be hardwired into the home except in obvious cases, e.g., the fridge door or the telephone as a likely constellation.

Locations are not the only solution for design dilemmas; however, they do provide a very rich, intuitive way for people to cope with information. People already understand the semantics of location within the home. It would be more difficult to move into a design that did not support this very natural tendency, especially in the home environment where people are resistant to change and to technology. Our design case studies show only two of the many ways that location can be applied to design.

Future work includes evaluating and continuing to develop the case study prototypes, including incorporating some of the expansions discussed in Chapters 5 and 6. This could also include the development of further prototypes, including completely new location-based designs as well as extensions to our existing ideas, such as different designs for

location-dependant information appliances (e.g. a lamp), or creating a picture frame based display that could both display StickySpots and be repurposed by location like FlowerPots. We would also like to look at incorporating our designs with existing systems and ideas, such as the Digital Family Portrait [Mynatt, 2001], GateReminder [Kim, 2004b] or a digital family calendar [Neustaedter, 2006]. As discussed in Chapter 6, we would then like to deploy some of these prototypes in real households for an extended period of time, to see how they are used, and if and how information management changes in the home when they are introduced.

Future work should also include taking our observations and incorporating them into the many existing theories surrounding communication and signs. We briefly discussed in Chapter 4 how contextual locations can be considered as indices using semiotics. Continuing to examine this connection could serve to enrich our understanding of locations, and help lead towards better design applications. Other theories that could be incorporated and used include cognitive theory, distributed cognition, communication theory, semantics, and even other HCI theory work, such as the Locales framework [Fitzpatrick, 1996]. Each of these theories relate to how people work together to understand information and location, and could provide enhancements and richness to the observations and ideas presented in this thesis.

In addition, future work should include extending and evaluating the location-based design guidelines begun here, so that they can be used as heuristics. These heuristics can then help designers evaluate existing technology and apply location-based design. Finally, as part of extending and evaluating the guidelines, further field study to extend the understanding of locations to include emotional, social and aesthetic aspects of home life would be extremely valuable.

7.4 Conclusion

Technology is becoming more and more pervasive in the home. Thus, the issues discussed in this thesis are very real, and very pertinent. Our results are significant for they offer designers and practitioners a more complete picture of information management and

routines in the home. We hope that our work will sensitize designers to the compelling implications that locations have for the design of future home information systems. We offer design avenues for communication information and have shown that it is important for future home information systems to either support locations or provide additional meta-data that locations typically provide. We have laid a foundation of knowledge which clearly suggests what will not work and should inspire methods that do work.

However, there is still much more to be understood about how people use technology and information in their homes. The work setting has been much more thoroughly explored, and technology is thus much better adapted to it. While home life is much more difficult to study, it is important that these issues continue to be explored.

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Appendix A. Home Study Documentation

This appendix contains all the relevant documentation from the home study run by Kathryn Elliot and Carman Neustaedter in the Spring of 2004. Please note that this thesis only discusses the results of Phase 2 of the study. Phase 1 relates to Mr. Neustaedter's work, and the results of that phase are described there. The contents of this appendix are as follows:

1. **Study Recruitment** letter given out to potential participants, to give them more information about the study.
2. **Demographics Questionnaire** given to participants prior to the interviews, in order to allow us to select a broad range of household demographics.
3. **Consent Form**, which was read and signed by all participants and, if necessary, their parents/guardians.
4. **Study Protocol** is a description of the methodology to be used in the study. This description includes both Phase 1 and Phase 2.
5. **Study Description** is the script used for the beginning of each interview.
6. **Potential Questions** is a list of possible questions to be asked of participants, again including both Phase 1 and Phase 2. These are not all the questions that were asked, as each interview was dependant on what was seen and discussed at the time. This is however a good sampling of the types of questions that were asked.

Appendix B contains a scan of the signed **Ethics Approval** for the study, approved by Janice Dicken, Chair of the Conjoint Faculties Research Ethics Board at the University of Calgary on March 18, 2004.

A.1 Study Recruitment

Investigators: Carman Neustaedter and Kathryn Elliot
Supervisor: Saul Greenberg

Experiment Purpose: The purpose of this research is to understand interpersonal communication between home inhabitants and their family and close friends. We would like to understand the social culture of this group and the mechanisms they currently use to stay in contact and coordinate activities with each other.

Procedure: You will be asked interview questions about your social relationships, e.g., family and friends, the communication mechanisms you use to maintain contact with others, and the areas of communication in your home. The interviews will take place in your own home where you can show the investigators the areas of communication in your home, e.g., your fridge door, the area around the phone, your answering machine. Photographs/videos will be taken of these areas with your permission.

Objective: The research objective is to design an electronic message centre for homes with the goal of supporting interpersonal communication. To achieve this, we need to first understand the social culture of domestic environments and the mechanisms currently used by home inhabitants for interpersonal communication. With this understanding we can design communication technologies for future "smart homes" which are socially appropriate and useful.

Commitment: Your participation in the study will take one to two hours and you will be compensated for your time with a payment equivalent to approximately $50 per family. For you to participate, we ask that all members of your household participate, with the exception of those under 12 years of age. The study will involve both group and individual

activities. Parents will be required to provide consent for minors and be present for all interviews with minors.

To Participate or For More Information:

Send email to: carman@cpsc.ucalgary.ca**,** elliotk@cpsc.ucalgary.ca

A.2 Demographics Questionnaire

The following demographics will be gathered about each household participating in the study. There will be no formal questionnaire – household members will simply be asked for this information at the beginning of the interview or during the recruitment process.

Household composition

Full-Time Members are people who live permanently at this address, with only short-term exceptions.

Number of Full-Time Members: ____

Part-Time Members are people who may only live at this address part of the time – i.e. children living under shared custody agreements, etc. They should be significant, permanent members of the household.

Number of Part-Time Members: ___

Ages of Household Members:

_____

_____

_____

_____

_____

_____

Scholastic Grade/Year and/or Occupations of Household Members:

_____

_____

_____

_____

_____

_____

Relationships between Household members (e.g., spouse, child):

_____

_____

_____

_____

_____

_____

A.3 Consent Form

Research Project Title: Interpersonal Communication in the Home

Investigators: Carman Neustaedter and Kathryn Elliot

This consent form, a copy of which has been given to you, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

Purpose: The purpose of this research is to understand interpersonal communication between home inhabitants and their family and close friends. We would like to understand the social culture of this group and the mechanisms they currently use to stay in contact and coordinate activities with each other.

Participant Recruitment and Selection:
To be a recruited for this study, we ask that you allow us to use and analyze your results from the study.

Procedure:
The study should require one to two hours of your time. You will be asked interview questions about:

1. your social relationships, e.g., family and friends,
2. the communication mechanisms you use to maintain contact with others, e.g., phone, email, instant messenger, notes, mail, and
3. the areas of communication in your home, e.g., the area around your phone, your fridge door, a bulletin board, a whiteboard, the front door, your computer.

The interview will require that you show the researchers specific areas and artifacts in your home that you use to communicate with others.

Confidentiality:

Your anonymity will be strictly maintained. Reports and presentations will refer only to a participant identification number and will be in a secure filing cabinet or on a secure computer. Confidential information (e.g., phone numbers, identifiable names) will be hidden from photos and videos prior to the publication of results from this study.

Risks:

There are no known risks, however, if you feel uncomfortable you are free to quit at any time. All information collected from a person that withdraws will be destroyed.

Investigators:

Carman Neustaedter is a PhD student and Kathryn Elliot is a MSc student, both in the Department of Computer Science at the University of Calgary. Their supervisor is Dr. Saul Greenberg, Professor in the Department of Computer Science.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation. If you have further questions concerning matters related to this research, please contact: Carman Neustaedter (carman@cpsc.ucalgary.ca), Kathryn Elliot (elliotk@cpsc.ucalgary.ca), or Dr. Saul Greenberg (saul@cpsc.ucalgary.ca)

If you have any questions or issues concerning this project that are not related to the specifics of the research, you may also contact the Research Services Office at 220-3782 and ask for Mrs. Patricia Evans.

Participant's Name	Date
Participant's Signature or Signature of Parent/Guardian	Date
Investigator's/Witness's Signature	Date

A copy of this consent form has been given to you to keep for your records and reference.

A.4 Study Protocol

Research Goals

1. To understand the culture of home inhabitants and their close friends and family as it relates to interpersonal communication.
2. To articulate design requirements for displaying interpersonal communication information in the home.

Study Methodology

Participant Selection

In order to obtain results that are applicable to as many households as possible, we intend to include one or more participant households from a variety of general categories including:

1. a young couple without children.
2. an older couple whose children have left home.
3. a family with 1+ school-aged (elementary/ junior high) children
4. a family with 1+ teenagers (high school)
5. a family with 1+ adult children who still live at home
6. a set of 2+ roommates

General Procedure

Participants will take part in an extended two stage interview. Stage 1 may take place separately, and may be done in the participants' home or in another location. Stage 2 will take place in the participants' homes.

All interviews will be semi-structured. We intend to have the participants talk about their homes and relationships using the artifacts that are present. While all participants will be asked a few specific questions to begin the interview and to elicit specific information, the interview will vary from one household to another as they show us the items and locations in their homes.

The interviews will involve all members of the household, excepting any children under the age of 12. Stage 1 will be done separately for each individual, excepting minors, who will be interviewed with their parents and/or guardians present. Stages 2 will be done with the household as a group.

Photos and/or video will be used to capture artifacts and locations of interest in all phases, with the participants' express permission.

Stage 1: Inner Social Network

Part A: General Classification of Relationships and Awareness

Please think about the people who you are interact with and maintain contact with in your life. On the board/piece of paper is a "social bullseye" with circles of varying sizes. The inner circle represents people who you like to maintain an awareness of on a daily basis. For example, knowing what activities the person is up to and how his/her life is going. The next circle is for people you wish to maintain a weekly awareness of. The circles continue out until a point where you wish to only know about a person about once a year or when major events occur.

Please write the names of people or groups of people inside the appropriate circle. If you feel a person or group overlaps to regions or moves between them frequently please indicate this by writing the name on the line between the two regions. If you feel there are missing rings in the bullseye, please feel free to add them in.

Please begin by filling in those people that come to mind. Once you have placed these people, please use your phone/address book or contact list(s) to fill in anyone you think you missed.

Part B: Temporal Classification of Relationships and Awareness

Please think about the people you have placed on your "social bullseye." On the piece of paper are a set of graphs showing how frequently you may interact with individuals. Please pick a graph for each of the people on your bullseye. If you feel none of the graphs match your communication frequencies with someone, please draw your own.

Stage 2: Interpersonal Communication in the Home

Please show me the areas in your home which you use to communicate with others. For example, places where you leave information for others and places where you receive information from others. These could include the fridge door, the location of the main household phone or answering machine, a bulletin or white board, your computer desk, a mantel or display area, doorways, or any other place you consider to be a location for messages, schedules, information etc. for members of your household.

A.5 Study Description

The following description should be read to each participant at the beginning of the study to inform participants of the procedures prior to giving consent. Italicized text are instructions to the investigator.

Introduce yourself.

- My name is _____, and I will be giving you instructions on what to do and will answer your questions.

- We're researching interpersonal communication between home inhabitants and their family and close friends. We would like to understand the social culture of this group and the mechanisms they currently use to stay in contact and coordinate activities with each other.

Tell them about the experiment.

- The study will involve an in-depth interview about the social relationships of you and your family, the communication mechanisms you use to maintain contact with others, and the areas of communication in your home. Throughout the study we will be taking notes and would like to take photographs/videos of communication areas in your home, given your permission.

Tell the participant that it's OK to quit at any time.

- If you feel uncomfortable you are free to quit at any time. Do you have any questions at this point?

Give them the consent form to sign. If it is not signed, do not proceed.

Proceed with the interviews.

A.6 Potential Questions

These questions will not be asked of every participating household. They are intended only as potential questions that may be asked to encourage participants to explain their inner social network and how they communicate within their home and within their network. Other questions will be asked based on responses and on the artifacts and locations within the home.

Possible Stage 1 Questions

- Is there a certain group of people that you are always interested in?
- Why are you interested in them?
- What makes people close to you (part of this group)? e.g., proximity, interaction, awareness.
- Do the individuals in this group change? Why/why not?
- How many people are in this group? Does this change?
- When does your group change?
- What information do you want to know about this social group? About individuals in this group?
- What do you expect from these people?
- How important is it that you know where they are and what they are doing?

Possible Stage 2 Questions

- How do you decide where to leave information for someone else?
- What information do you leave for others?
- Where do you receive information from others?
- Where do you prefer to receive information from others?
- What information do you receive from others?
- How do you know who is home or who is around?

- Please show us where you leave phone messages. Is it the same for everyone? What about answering machine messages?
- Please show us you look for messages for you. Are there multiple places? How do you know these messages will be left in this location?
- Please show us where you leave mail that is for you and where you would leave mail for others. Where do others leave mail for you?
- Please show us where you deal/work with messages. ie. Where do you open your mail? Where do you respond to phone messages?
- Please show us where you post information for ALL members of your household? Do you put it in one location or does it move from location to location as different people see it?
- How do you coordinate scheduling? Please show us where you put calendars, schedules etc. How often do you look at this information?
- If you had an important message for one member of your household, where would you leave it? How would you ensure that they had received it? How would you draw their attention to it? Will you show us these locations?
- If you had something really important for everyone in your house to see immediately, where would you leave it? Please show us how would you draw their attention to it?
- If you had a private message for one member of your household, where would you leave it? Why?
- If you could allow people you were close to, but who do not live with you to post information in your home, where and how would you let them display information they wanted to share with you? What kinds of information would you want to have them share with you?
- Would you ever want to share information from your home with people you are close to but do not live with? How do you currently do this?
- If you could put information in one location within your home, and have these people receive it, where would that location be? How would they receive it?
- What kinds of information would you share with them? Would this differ from person to person?

- Do you have a message centre? i.e. a main place where messages accumulate? Please show us.
- Why is this your message centre? Is it where you look for messages the most often? Is this where messages are generated? Where they are left and received?
- Please show us what kinds of messages are used here? What kinds are used elsewhere?
- Why did you choose this location? Is this a high traffic area of your household? Is it central? Is this a place that all members of your household congregate?
- How often do you look at/check your message centre? How often do you expect others to look at/check it?
- Do you use your message centre for coordination of activities? i.e. quick notes, schedules, carpool lists etc. If not, do you have another location or locations for this? Please show us these locations.
- Do you use your message centre for displaying items you want to share with the rest of the household? i.e. certificates, children's artwork, grades, pictures, invitations, thank yous, postcards. If not, do you have another location or locations for this? Please show us.
- Please show us where you display important information you need frequently/occasionally/rarely? i.e. school office phone numbers, family contact lists, work schedules, etc. If not, do you have another location or locations for this?
- Where do you work with messages? i.e. answering phone calls, paying bills, writing letters, replying to emails, etc.

Appendix B. StickySpots Architecture

In this section, I will briefly describe the architecture for StickySpots, the location-based messaging system discussed in Chapter 5. First I will discuss the toolkits used to build the system. Following that, I will describe the data and objects used. Third I will describe the subscriptions and notifications. Finally I will present an example of how these components work together.

Toolkits

StickySpots was built using three prototyping toolkits. First, GroupLab.Networking [Boyle, 2006] enables the creation of a server to share information between the instances running at each home location. This server is a shared dictionary notification server, meaning that information is stored in the server as key/value pairs. Each instance subscribes to relevant keys, and is notified when that key, or any key underneath it in the structure, is added, changed or removed. The instance can then download the new information. Second, the Collabrary toolkit [Boyle, 2005] enables the multimedia picture functionality used in the image and web stickies. This toolkit compresses the images to send them through the shared dictionary easily. Third, StickySpots uses the Phidget RFID readers and tags [Greenberg, 2001] to identify people. All of these toolkits are designed to support rapid prototyping of a wide variety of interfaces. They were ideal for use in this project, as my goal was to use this design as a case study in how to apply contextual locations to design.

In addition to these prototyping toolkits, StickySpots also uses the Microsoft Tablet PC development kit to create and manipulate the ink values.

Data and Objects

StickySpots is written in C#. It is built as a single main form (the black background form seen when starting the program) onto which the various note component objects are placed.

Each type of note (ink, image or web) is a separate component, reflecting the differences in the data required.

All sticky notes contain the same base set of data. These are a hexadecimal background colour value, a unique GUID value to identify the note, a date and time value for when the note was sent, the location the note came from, and the location and/or person the note was sent to. The ink notes add a tablet ink value to that, represented as a string. The picture and web stickies each have a picture value, and the web sticky also has a web address string. These values are stored within the objects and are reflected in the shared dictionary.

Each instance – or each location – has a set of meta-data stored in the shared dictionary. This information is currently limited to the location name and whether or not anyone has signed in to receive their personal messages at that location. It is placed there so that locations can know about each other. Currently this is only used to generate the list of locations that messages can be sent to, but it is also intended to easily facilitate extensions to the system. For instance, one possibility is to add the ability to show thumbnails of other locations, so users could see if their message had arrived, what activity was taking place in other locations, etc. This could provide an overview of the messages in the home. It would be easy to extend the information stored about each location to provide this kind of functionality.

Subscriptions and Notifications

Each location instance is subscribed to four different key sets. The first is the location set described above. Every instance therefore receives a notification when another location is added or removed. The other three keys are for the three types of sticky notes. When a notification is received on any of these keys, the instance checks to see if it matches the message's intended location, or (if someone is signed in at that location) whether the message is intended for the person signed in at that location. If either of these cases are true, the instance creates a new component of the correct type for that sticky and posts it to a random location on the form with a "halo" around it to indicate that it is new.

Walk-through Example

As an example of how these components and subscriptions work together, we will return to the example given in Chapter 5 of Anne sending a phone message sticky to her daughter Catie. Anne sends the inked message from the living room to the kitchen.

The shared dictionary has already been started. It can run on the same computer as one of the location displays or it could be on a separate machine. All instances will need to know where the server is running so they can provide the proper IP address when they connect. It is also possible, regardless of where the server is, to have several instances of StickySpots running on the same computer – e.g. two different displays, in different locations can be connected to the same computer without problems.

When the living room StickySpots instance signed in to the shared dictionary, it posted three keys:

```
/location/living room/name (value = “living room”)
/location/living room/public (value = true)
/location/living room/owner (value = “”)
```

This notifies other locations that the living room is signed in, and that no one is currently receiving their personal messages at that location. The living room instance then looks in the shared dictionary to see if there are any messages currently there that are intended for this location. If there are, it creates the appropriate type of component and downloads the information needed from the shared dictionary. This location also subscribes to the location key, the message key, the picture key and the web key (as well as all keys below these).

When Anne creates the message for Catie and hits send, the information from the sticky note she created is sent to the shared dictionary as the following keys:

```
/message/guid (value = a unique generated string)
/message/guid/backcolour (value = “light blue”)
/message/guid/date (value = the date the note was sent)
/message/guid/time (value = the time the note was sent)
/message/guid/fromlocation (value = “living room”)
/message/guid/ink (value = a string representation of the ink)
/message/guid/owner (value = “”)
/message/guid/location (value = “kitchen”)
```

Since all instances are subscribed to the message key, they all receive a notification that a new message has been posted. Each location checks the "/message/guid/location" key value to see if it matches. The kitchen instance finds that it does, so it creates a new sticky component and downloads the values to post them. The back colour value is used to colour the posted sticky, the date, time and "from location" are used to create the label at the top of the sticky (as well as the tooltip that pops up on a single click), and the ink value is translated back from the string representation to its original form. This sticky is then posted/displayed on the main form. The placement of the note is chosen randomly, and a halo is drawn around it to indicate that it is new (as shown in Figure 5.6).

The picture and web stickies work in exactly the same way. The picture keys include the following kinds of information:

```
/picture/guid (value = a unique generated string)
/picture/guid/backcolour (value = the sticky's backgroun colour)
/picture/guid/date (value = the date the note was sent)
/picture/guid/time (value = the time the note was sent)
/picture/guid/fromlocation (value = the location the note came from)
/picture/guid/image (value = a compressed version of the image)
/picture/guid/owner (value = the person the sticky is for)
/picture/guid/location (value = the destination location)
```

These keys are almost identical to those in the message keys, with the exception that there is no ink value, and an image value is added to contain the image that will be displayed. The web keys are again very similar, with the addition of a key to contain the URL of the represented web page:

```
/web/guid (value = a unique generated string)
/web/guid/backcolour (value = the sticky's background colour)
/web/guid/date (value = the date the note was sent)
/web/guid/time (value = the time the note was sent)
/web/guid/fromlocation (value = the location the sticky came from)
/web/guid/image (value = a compressed version of the web screenshot)
/web/guid/owner (value = the person this sticky is for)
/web/guid/location (value = the destination location)
/web/guid/url (value = the web URL)
```

When a notification is received on the "/picture/" or "/web/" key, the location checks to see if it is intended for that location, and if so, creates a new picture or web note component

and downloads the relevant information. When a note is deleted, the keys corresponding to it are removed from the shared dictionary.

When someone signs in to receive their personal messages, either through the dialog provided or by swiping their RFID tag, a region is drawn on the main form to contain those messages. Similar to when a location signs in, the instance checks to see if any of the messages currently in the shared dictionary have an owner value corresponding to the person who just signed in. If there are any such messages, it downloads the information and creates the appropriate components. There are no new subscriptions involved. Instead, when a notification is received on any of the "/message/", "/picture/" or "/web/" keys, the location instance not only checks if the "/message/guid/location" key is a match, it also checks if the "/message/guid/owner" key is a match to the person signed in at that location. If so, it creates a sticky component in exactly the same way as for the location, with the exception that the initial note placement and movement are restricted to the confines of the drawn region. Messages intended for a location only (like our Anne and Catie example) will have a null value in the owner key (as in the example). Messages intended only for a person with have a null value in the location key.

Overall, StickySpots is a fairly simple system. The goal was to show one way that the ideas from Chapters 3 and 4 can be applied to design. The system is fairly easy to extend – for instance to add another type of note (e.g. audio or plain text) or to do the kind of location overview discussed earlier. It is intended to be simple and flexible in order to show potential users and designers the possibilities of location-based design.

Appendix C. Ethics Approval

UNIVERSITY OF CALGARY

CERTIFICATION OF INSTITUTIONAL ETHICS REVIEW

This is to certify that the Conjoint Faculties Research Ethics Board at the University of Calgary has examined the following research proposal and found the proposed research involving human subjects to be in accordance with University of Calgary Guidelines and the Tri-Council Policy Statement on *"Ethical Conduct in Research Using Human Subjects"*. This form and accompanying letter constitute the Certification of Institutional Ethics Review.

File no:	**CE101-3914**
Applicant(s):	**Carman Neustaedter**
	Kathryn Kylie Elliot
Department:	**Computer Science**
Project Title:	**Interpersonal Communication in the Home**
Sponsor (if applicable):	

Restrictions:

This Certification is subject to the following conditions:

1. Approval is granted only for the project and purposes described in the application.
2. Any modifications to the authorized protocol must be submitted to the Chair, Conjoint Faculties Research Ethics Board for approval.
3. A progress report must be submitted 12 months from the date of this Certification, and should provide the expected completion date for the project.
4. Written notification must be sent to the Board when the project is complete or terminated.

Janice Dickin

Janice Dickin, Ph.D, LLB,
Chair
Conjoint Faculties Research Ethics Board

March 18, 2004
Date:

Distribution: (1) Applicant, (2) Supervisor (if applicable), (3) Chair, Department/Faculty Research Ethics Committee, (4) Sponsor, (5) Conjoint Faculties Research Ethics Board (6) Research Services.

Appendix D. Co-Author Permission

UNIVERSITY OF CALGARY

July 25, 2006

University of Calgary
2500 University Drive NW
Calgary, Alberta
T2N 1N4

I, Saul Greenberg, give Kathryn Elliot permission to use co-authored work from our papers, "Time, Ownership and Awareness: the Value of Contextual Locations in the Home", "Building Flexible Displays for Awareness and Interaction" and "StickySpots and Flower Pots: Two Case Studies in Location-Based Home Technology Design," for Chapters 3, 4, 5 and 6 of her thesis and to have this work microfilmed.

Sincerely,

Saul Greenberg

UNIVERSITY OF CALGARY

July 25, 2006

University of Calgary
2500 University Drive NW
Calgary, Alberta
T2N 1N4

I, Carman Neustaedter, give Kathryn Elliot permission to use co-authored work from our papers, "Time, Ownership and Awareness: the Value of Contextual Locations in the Home and "StickySpots and Flower Pots: Two Case Studies in Location-Based Home Technology Design," for Chapters 3, 4, 5 and 6 of her thesis and to have this work microfilmed.

Sincerely,

Carman Neustaedter