Understanding How to Design Awareness Groupware for the Home

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ABSTRACT
People naturally maintain an awareness of the location, activities, and emotions of their family and friends. We call this *interpersonal awareness:* a naturally gained understanding of the social relations of one's social contacts. This awareness is vital in home life for it provides family and friends with: an understanding of how to best move into interaction with one another, knowledge needed to coordinate and plan activities, and feelings of connectedness and comfort. We build on this existing model of interpersonal awareness to articulate a set of design guidelines that describe how groupware should be designed to support interpersonal awareness in the home. Specifically, we show how awareness groupware should be designed as simple and reliable *awareness appliances* that can provide meaning and interaction by being *embodied* in everyday domestic routines. We also discuss how designs should support *contextual locations* within the home while ensuring users maintain adequate *control and feedback* over awareness information.

Author Keywords
Interpersonal awareness, ubiquitous groupware, home technologies, contextual locations

ACM Classification Keywords
H.5.3. Group and Organization Interfaces: computer supported co-operative work.

INTRODUCTION
Communication technology has been identified as a prime area for technology design in the home (Crabtree et al 2003, Hutchinson et al, 2003). However, we cannot simply migrate ideas from the office environment into the home. Instead, technologists must have a rich understanding of the domestic routines of home inhabitants in order to design technologies that are useful, usable, and socially appropriate for the home.

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The particular aspect of home communication that we are interested in is *interpersonal awareness*: a naturally gained understanding of the location, activity, and status (e.g., emotions, health) of one's personal contacts. This awareness extends from one's home inhabitants all the way to one's extended social contacts where the amount of awareness varies depending on the interpersonal relationship. For example, a husband may desire to know the general whereabouts of his spouse throughout the day, while an adult child may want to know how her mother's health is. Interpersonal awareness is vital in home life for it helps people coordinate activities and provides people with feelings of connectedness and comfort.

Through our own empirical work (Neustaedter et al, 2004, Elliot et al, 2004) and that of others, we have found that interpersonal awareness is gathered using one or more of the following techniques:

face-to-face interaction: when people are co-located with their social contacts they naturally converse and share awareness information;
mediated interaction: when separated by distance, people use handwritten notes and messages or technology such as the telephone, email, or instant messenger to maintain awareness; or,
visual cues from domestic artifacts: by observing the presence, absence, or status of artifacts in the home, awareness information is often naturally understood without direct interaction.

Interpersonal awareness can be difficult to maintain when people become separated by distance or time. Moreover, the current techniques for gathering interpersonal awareness are often time consuming because people typically have to rely on direct conversational techniques. To this end, we suggest the design of lightweight technologies that people can use to easily gather awareness information about their family and friends.

In this paper, we build on our existing model of interpersonal awareness by describing several design guidelines which are aimed at providing designers and

1. Designing for Simplicity	2. Designing for Information Mobility and Contextual Locations	3. Providing Appropriate Context-Awareness	4. Providing Meaning and Interaction Through Embodiment
Create simple and reliable designs to ensure success in the home;	Design devices that are easily moveable, mobile devices themselves, or are part of an integrated set of devices	Use contextually-based input to sense awareness information;	Design awareness devices to be easily embodied within domestic culture;
Create each design as an information appliance that focuses on presenting only one type of awareness information	Allow the locations of these devices to automatically provide rich meta-data to enhance the awareness information	Provide adequate feedback and control over the awareness information being acquired and presented	Interaction should be directly with the device, just as the effect of the interaction is visible within the device

Table 1. A summary of the four design guidelines for interpersonal awareness groupware.

practitioners with insight into how to design useable awareness groupware for the home.

MOVING TOWARDS DESIGN

It is clear that we should design technologies in an attempt to address one or more of problems people typically face when gathering interpersonal awareness: time separation, distance separation, or time limitations. These designs should also pay close attention to provide the specific types of awareness information that people desire to know about, described in Neustaedter et al (2004).

What is not so clear, however, is how these awareness technologies should be designed in order to make them enhance and not hinder the day-to-day domestic routines of home inhabitants. We address this question by discussing four general guidelines for the design of interpersonal awareness groupware systems for the home:

1. ***designing for simplicity:*** creating awareness appliances that are simple and reliable to use;
2. ***designing for information mobility and contextual locations:*** creating awareness systems that can provide awareness information in a variety of locations;
3. ***providing appropriate context-awareness:*** creating awareness systems that provide an adequate level of feedback and control over the acquisition of awareness information; and,
4. ***providing meaning and interaction through embodiment:*** creating awareness devices that can easily become a part of everyday life.

These guidelines are based on existing theories, observations of domestic culture, and lessons learned from technology design. Their primary purpose is to provide insight into how interpersonal awareness groupware systems can be designed so that they are successful and easily integrated into everyday domestic routines.

We now describe the details of each of our design guidelines in turn. A summary of the main concepts can be found in Table 1.

Designing for Simplicity

The first design guideline is about the presentation of awareness information. To illustrate this guideline, we describe the success of home appliances and the move towards information appliances. We conclude by applying this knowledge to interpersonal awareness groupware design.

The Success of Home Appliances

Several researchers have begun investigating the design of a future "smart home" and have even designed special test bed homes from the ground-up reflecting their visions of an interconnected home with sensing capabilities and embedded technology (Mozer et al, 1995, Kidd et al, 1999, Intille, 2002). However, one could argue that this so-called smart home is already upon us. Rather than being built from the ground-up by designers, engineers, or contractors, smart homes are being created by everyday people piece-by-piece. These homes have become "accidentally smart" (Edwards and Grinter, 2001).

This misconception of the smart home could simply be because computational technology has become so embedded that often we do not notice it. Take, for example, many of the simple home appliances you use throughout a given day, such as the microwave, coffee maker, oven, fridge, or television. These items (at least new versions of them) already have microprocessors embedded inside of them and may even be smarter than you think. These smart technologies are already in our homes and perhaps what is more important is that they have been able to move into our homes and become part of our domestic routines with great amounts of success (Venkatesh, 1996).

These devices are largely successful because they are, for the most part, simple and reliable (Venkatesh, 1996, Edwards and Grinter, 2001). This is quite evident when home appliances are compared to the modern PC that has also made its way into the home. For example, ask yourself these questions. How long can you go before receiving an error message on your computer through simple daily use? When using your computer, how often do you wish you had a member of a technical support team standing at your side? Likely these types of events occur at least once a day, if not several times a week. In contrast, when was the last time your microwave gave you a warning message? Or, when was the last time you wanted to call a "microwave specialist" to understand how to cook something? These types of events, for the most part, do not happen. Home devices are typically much more reliable than computer software (Edwards and Grinter, 2001).

There are, of course, technologies in the home where this is not the case. Take the VCR as an example: informal observations have shown that children often find it easier to operate the VCR than many parents. Yet, you don't often see the VCR pop-up an error message that says you have performed an "illegal operation." Despite counterexamples like these, the general conclusion is still the same: home technologies are successful when they are simple and reliable.

From Convergence to the Information Appliance

There have been two largely debated paradigms for designing home information technologies of the future: *convergence* and *information appliances* (Norman, 1998, Dourish, 2001). The idea of convergence is that future computational devices should be multi-purpose and generic. The modern PC provides one example of convergence (Dourish, 2001). People are able to install a wide variety of software on their PC for a multitude of tasks, including word processing, accounting, graphic design, and much more.

The other paradigm, information appliances, focuses on designing single purpose devices where the goal is presenting information (Norman, 1998). This idea is quite contrary to the modern PC (Dourish, 2001). While appliances lose the flexibility and power that the convergence paradigm offers, this paradigm gains an edge by focusing on providing devices that are simple to use, versatile, and pleasurable, e.g., people should enjoy using them (Norman, 1998). The goals for information appliances offer a similar point of view as the success stories of home appliances. In both, simplicity is at the forefront. It is this simplicity that makes the information appliance paradigm largely attractive for the design of interpersonal awareness groupware.

Applying Simplicity to Interpersonal Awareness Groupware

While the above can be applied to the design of home technologies in general, it is particularly applicable to the design of interpersonal awareness applications. Many of the techniques people already use to gather awareness are generally lightweight. This is especially the case when gathering an awareness of home inhabitants: short-hand interactions or visual cues provide a rich level of awareness. By designing simple *awareness information appliances*, we can provide users with similar lightweight mechanisms to gather awareness. Simple is not enough though. With simplicity comes the expectation of reliability (Tollmar and Persson, 2002); thus, awareness appliances should also be designed to be highly reliable.

This brings us to the first design guideline for interpersonal awareness groupware: *interpersonal awareness groupware should be designed to be simple to use and reliable.* This means more than just being easy to use and robust though, for all applications should have this as a focal point. Rather, this means designing interpersonal awareness groupware as information appliances that present the user with one specific type of awareness information for a limited set of people, be it home inhabitants, intimate socials, or a group of extended socials. The importance of this is that awareness appliances should *not* be designed to present all aspects of awareness within a single device; this would make appliances overly complex. This guideline also means that awareness information should be presented on appliances found throughout the home and not just on the standard PC in the home office.

Several interpersonal awareness appliances have already been created that exploit this design guideline (e.g., Go et al, 2000, Mynatt et al, 2001, Hindus et al, 2001, Siio et al, 2002, Tollmar and Persson, 2002). Typically awareness information is presented as part of an aesthetically pleasing domestic artifact like a picture frame, lamp, or plant found throughout the home. Of the appliances that have been deployed and evaluated in the field, user feedback has generally been quite positive (Mynatt et al, 2001, Tollmar and Persson, 2002).

Designing for Contextual Locations

The second design guideline provides insight into where awareness groupware should be designed to be placed within the home. We discuss communication locations within the home, the role these contextual locations play in domestic routine, how to design for contextual locations, and how this knowledge can be applied to the design of interpersonal awareness systems.

Communication Information in the Home

Communication information in the home primarily resides in one of more of three general areas: *ecological habitats, activity centres,* and *coordinate displays* (Crabtree et al, 2003a). *Ecological habitats* are the locations in the home where communication media live and home inhabitants go to locate various resources, e.g., the mail, computer. These locations are typically areas like the kitchen table, kitchen counter, fridge door, or work desk (Crabtree et al, 2003a).

Activity centres are the locations in the home where communication media are actively used or handled, e.g., a bill is paid, an email is read. These locations are usually areas such as the kitchen table, work desk, or couch. They may overlap with ecological habitats, but this is not always the case (Crabtree et al, 2003a). *Coordinate displays* are locations where people place things for others to see, often in an effort to coordinate activities, e.g., postcards, bills that need to be paid, grocery lists. Every home has these three main places of communication, yet their actual location is specific to each home and the daily routines of its inhabitants (Crabtree et al, 2003a). Of vital importance is the realization that information within the home is not fixed in one location, information is highly mobile throughout a variety of locations.

The Role of Contextual Locations

The places of communication in the home, or contextual locations, are vital for they provide home inhabitants with a rich set of meta-data that helps people organize and deal with information (Elliot et al, 2004). Contextual locations can augment awareness information with an implicit understanding of *time* and *ownership* (Elliot et al, 2004). *Time* refers to the ability of a location to provide an understanding of the relevance and dynamics of a particular piece of information. That is, people can tell by the location of a piece of information if it is something they need to deal with immediately, if it can wait until later, or if it has already been dealt with (Elliot et al, 2004). *Ownership* is the ability of a location to provide an understanding of the intended recipient for a piece of information. People typically have their own personal or private spaces within the home. Home inhabitants are often aware of this and will place items for others in locations where the intended recipient will likely see them (Elliot et al, 2004).

Providing Location-Oriented Designs

This understanding of locations in the home articulates the fact that people already have well-established places where information is typically placed, consumed, or displayed for others in their home (Crabtree et al, 2003a). These contextual locations have embedded in them a shared understanding between home inhabitants (Elliot et al, 2004). Designers cannot enforce where communication technology will be placed in a home; however, they can design technology that is capable of easily fitting into these social places regardless of their physical location (Elliot et al, 2004). In the case where this is difficult or impossible, designs can present users with digital analogues of the rich meta-data that is provided by contextual locations (Elliot et al, 2004).

Location-Oriented Awareness Designs

Awareness information is already one of several types of communication information naturally found in the home, e.g., the presence or absence of artifacts can tell who is not currently home (Elliot et al, 2004). However, we can enhance this aspect of domestic culture by creating awareness appliances that provide additional awareness details, either about home inhabitants or other social contacts. These designs should be created based on an understanding of contextual locations and the notion that information is highly mobile within the home.

Thus, our second design guideline states that: *interpersonal awareness groupware should be designed to support information mobility and contextual locations.* This means that awareness appliances should be designed in a way that allows them to be: easily moved from place to place within the home, mobile devices themselves (e.g., awareness information could be provided on a wearable device), or an integrated set of awareness devices placed throughout the home that permits information to move between them. This freedom will allow awareness appliances and, in turn, the awareness information to migrate to the location most suitable for a particular home's domestic routine, thus providing information mobility. Once these devices are a part of the household routine, they will benefit from the meta-data provided naturally by contextual locations.

Providing Appropriate Context-Awareness

The third design guideline addresses the problem of acquiring interpersonal awareness information. We discuss the use of context-aware systems for automatically sensing information, the role of control and feedback of context, and the use of context-aware technology as input to interpersonal awareness systems.

Automating Input through Context-Awareness

One difficult challenge facing awareness groupware is the acquisition of awareness information. Explicit user input can provide highly accurate awareness information, yet it can be time consuming and easily forgotten over time. An alternative is to automate the acquisition of awareness information through some type of context-aware system. These systems use simple sensors, computer vision techniques, or other automated processes to automatically detect the user's context (Dey et al, 2001). This sensed context is generally comprised of one or more of the following (Abowd and Mynatt, 2000, Dey et al, 2001):

- ***Identity:*** who is currently present in a particular context, be it a single individual, a group of people, or some other object within the context;
- ***Location:*** where the current context resides, e.g., a room, a building, or other location-type attributes such as the position, orientation, or proximity of entities within the context;
- ***Status (or activity)***: the state or activity of the entities within the context, e.g., the temperature of a room, a person's current activity; or,
- ***Time:*** whether a contextual description is about past events (historical), the current situation, or predicted future situations.

Using this context, systems are able to present users with contextually-appropriate information and services, or automatically execute services on the behalf of users (Dey et al, 2001). For example, as two people sit down at a meeting table the light above the table may turn on automatically (Koile et al, 2003). What should be clear is that the interpersonal awareness information desired by individuals fits the model of context that is used in context-aware systems. This makes it natural to try and leverage context-awareness for interpersonal awareness groupware, yet this can easily lead to problems.

The Problems with Context-Aware Systems

While the automation of awareness gathering is promising, two main problems currently exist with the use of context-aware technology. First, context-aware systems typically face inference problems. Human behaviour is complex and even the "smartest" computer has difficulty sensing and understanding socially-based information (Bellotti and Edwards, 2001, Greenberg, 2001, Svanaes, 2001). Second, people are often left out of the control loop of context-aware systems (Bellotti and Edwards, 2001, Erickson, 2002). That is, they are often not knowledgeable of what information is being sensed, how it is be sensed, and what is happening with this sensed information. Because of this, users are left unintelligible and unaccountable for their actions (Bellotti and Edwards, 2001). In the case of awareness groupware, one could imagine a system that provides inappropriate awareness information to particular individuals without the user knowing.

Providing Control and Feedback of Context

In order to circumvent the problems inherent in context-aware systems, designers must come to the realization that context inference is far from perfect and mistakes will occur. Thus, systems should first provide users with *feedback:* an understanding of what the system is capable of sensing, what the system is currently sensing, how it knows this information, and what it is doing with it (Bellotti and Edwards, 2001). Similarly, context-aware systems should provide users with *control*: the ability to select what context is sensed, what devices are used for sensing, how the sensed information is used, and who knows about the sensed information (Bellotti and Edwards, 2001). Context-aware systems should also provide the user with opportunities to control how context is inferred, especially in the case of uncertainty. In these situations, the user should be able to confirm automatic actions or be presented with a choice of system actions (Bellotti and Edwards, 2001).

Context-Aware Interpersonal Awareness Devices

Context-aware technology presents one means for automatically acquiring awareness information that can be presented to one's social contacts. One could imagine automatically acquiring awareness information through sensors placed in a home, or even acquiring information through one's existing applications, e.g., an electronic calendar. This may lessen the burden of explicitly providing awareness information to others. However, not all aspects of interpersonal awareness can be inferred in this way; it is impossible to sense and infer human thoughts and feelings. Other, simpler, context attributes such as one's current or past location or activity could be sensed and presented to one's social contacts as desired. Naturally, context-aware interpersonal awareness systems must be carefully designed to avoid the common pitfalls associated with context-aware computing.

Thus, our third design guideline states that: *interpersonal awareness groupware can leverage context-aware technologies, but only if adequate control and feedback is provided.* This means that awareness applications can use contextually-based input, yet it is an absolute requirement that users be provided with an adequate understanding of the awareness information that is being sensed, how it is being sensed, and who has access to it. Just the same, users absolutely must have adequate control over what awareness information is sensed, how it is sensed, and who has access to it.

We stress the word *adequate* in this design guideline for users should not be overwhelmed or burdened with requirements to always take control or know intricate details about what is being automated. The level of control and feedback needed should be dependent on the information being shared and the parties involved in the sharing. For example, imagine a system that uses the presence of one's keys by the doorway to provide family members with knowledge of who is at home. In this case, it may not be necessary to provide a high degree of feedback that this is in fact occurring because family members already naturally acquire this information when at home.

Providing Meaning and Interaction through Embodiment

The fourth design guideline describes why awareness appliances should be designed to be embodied within our everyday world. We discuss embodied interaction, how embodiment provides meaning, what it means to interact with embodied systems, and how this knowledge can be applied to the design of interpersonal awareness systems.

Embodied Interaction

A new paradigm for the design of interactive systems is *embodied interaction.* Embodied interaction attempts to shift the focus of system design to a user-centred approach where interaction with systems is designed in a manner that does not compromise human abilities in the effort to soften the workload placed on the computer (Dourish, 2001). Embodied interaction is about designing systems that are embedded in our everyday social and physical world where our interaction with them takes advantage of this embodiment (Dourish, 2001). This comes naturally from the fact that we as humans are a part of this world and to design truly intuitive systems our interaction with them should be in the everyday world as well.

When we interact with objects in the world we learn about them and receive meaning from them through our interactions. This is because they are embodied. For example, you are able to pick up an apple and interact with it because it is a part of the world in which you live. By interacting with the apple, such as biting it, you learn the apple is crunchy and sweetly tasting (depending of course on the type of apple). This meaning is presented to you by the apple simply because it is a part of your world and you are able to interact with it (Dourish, 2001).

Social aspects of life are also embodied in our world (Dourish, 2001). Take, for example, a simple conversation between two people. Here there is more to the conversation than just the words that are spoken. Both people will elicit a variety of non-verbal behaviors indicative of such things as turn taking or interest level where the behaviors will typically be understood by both parties. The conversation also has a rich social meaning based on its given context: it is taking place in a particular location, is about a particular topic, and is likely influenced by the interpersonal relationship shared by the two individuals. It is because the conversation is embodied in the real world that it carries this rich level of meaning.

Designing for Embodiment

When systems are designed to be embodied, they can provide similar aspects of meaning to users. This meaning can guide them in how to use the interface by enforcing or influencing the user's conceptual model and providing physical affordances that make clear the possible interactions available. This meaning can then be used by people to create a shared understanding with others or develop a shared practice around the technology (Dourish, 2001). Embodied interaction is not about providing this meaning at the time of design however. Meaning is not created by designers. Rather, embodied interaction is about designing a system so that it can give rise to meaning as users interact with it. Systems that are truly embodied in both the physical and social world will provide users with a means to establish and share meaning through actual practice. This idea is emphasized by studies of domestic culture that show domestic artifacts receive their meaning over time through their everyday usage (Tollmar and Persson, 2002, Crabtree et al, 2003b).

Interacting with Embodied Systems

When users interact with an embodied system, this interaction is embodied as well. That is, the interaction takes places through and on the system where natural human input like handwriting, speech, gesturing, or the manipulation of physical artifacts can be used as sources of interaction (Fishkin et al, 1998, Abowd and Mynatt, 2000, Dourish, 2001, Shafer et al, 2001). This idea differs from tangible computing in terms of the directedness of the interaction. In tangible computing, one generally interacts with an object and the effect of this interaction is seen elsewhere. In embodied interaction, the effect is seen within the same object (Fishkin et al, 1998).

An example whiteboard application illustrates this point. Imagine two versions of the system. In the first, a user can draw on a small slate using a stylus for input. The writing then appears on a large wall display. In the second, the user stands in front of the wall display and, with a stylus, writes directly on the display. In the first case, although the interaction is directly on an object, namely the writing slate, the effect is not seen within this same object. In the second case, however, both the interaction and effect of this interaction are embodied in the same device, the large wall display. This second approach illustrates interaction in embodied systems while the first demonstrates interaction in tangible computing.

The Embodiment of Interpersonal Awareness

Interpersonal awareness is inherently a part of both our physical and social worlds. It is manifested in our interpersonal relationships, our everyday routines and interactions that see us gathering and maintaining awareness, and our domestic environments that present an imprint of our lives as awareness information for others. Interpersonal awareness groupware can benefit from designs based on embodied interaction.

For this reason, our fourth design guideline states that: *interpersonal awareness groupware should be designed to provide meaning and interaction through embodiment.* This means first and foremost that awareness appliances should be designed in a manner which allows them to easily become a part of everyday domestic routines. This has proven to be a requirement for successful domestic technologies (Venkatesh, 1996, Edwards and Grinter, 2001). By being a part of domestic routines, awareness appliances will naturally afford meaning to users. Our model of awareness articulates such routines as do other studies of communication in the home, yet it is important to realize that each person's routine will have its own subtleties (e.g., Crabtree et al, 2003, Elliot et al, 2004).

This guideline also has implications for interaction with awareness appliances. If awareness appliances are to truly be embodied within everyday life, user interaction with them should also be embodied. It is not necessarily the case that a keyboard and mouse will be available for this interaction. In fact, such input devices would be awkward to use in the home with ubiquitous technologies. Rather, interaction with awareness appliances should be directly on the appliance, either through physical manipulation, handwriting, or other direct input mechanisms.

Several technologies have already utilized this design guideline for providing awareness. Tollmar and Persson (2002) embody the remote presence of distributed family members in a physical lamp based on the observation that the on / off state of a light can typically be used to know whether someone is at home or not. Mynatt et al (2001)

embody awareness information such as the levels of remote activity of aging parents within a digital photo album, where family members may routinely look when thinking about a loved one.

There is a natural counterargument to this guideline that suggests that designing technology to fit into existing routines has the potential to stunt innovation. This statement is true, yet the alternative can easily lead to designs that are not used because they do not present information at the appropriate location or time. We would argue that such designs do not fit into everyday life and are not truly embodied. Designing for existing routines is a natural starting point for awareness design as people can adapt routines over time as they find new ways to use the technology.

CONCLUSION

This paper builds on our existing model of interpersonal awareness by describing four design guidelines that can be used to guide the design of interpersonal awareness groupware for the home. These guidelines identify how and why interpersonal awareness applications should: be designed as information applications that are simple and reliable; be designed for information mobility and contextual locations within the home; use appropriate context-awareness as input to the system; and, provide meaning and interaction through embodiment. Awareness systems designed based on these principles should stand a high chance of being successfully integrated into domestic culture with the home. It is important to realize that though that these design guidelines are tightly coupled and all should be considered when designing awareness groupware for the home. Moreover, they should be applied to designs based on the real user needs found in our model of interpersonal awareness.

This work provides designers and practitioners with a detailed understanding of how home technologies can be designed to support interpersonal awareness. Moreover, many of the concepts and ideas presented in these design guidelines may be applicable to home communication technologies in general.

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REFERENCES

1. Abowd, G.D., and Mynatt, E., (2000) Charting Past, Present, and Future Research in Ubiquitous Computing, *ACM Transactions on Computer-Human Interaction*, 7 (1), pp. 29-58.
2. Bellotti, V., and Edwards, K., (2001) Intelligibility and Accountability: Human Considerations in Context-Aware Systems, *in Human-Computer Interaction, Special Issue: Context-Aware Computing*, Volume 16, Numbers 2-4, pp. 193-212.
3. Crabtree, A., Rodden, T., Hemmings, T., and Benford, S., (2003) Finding a Place for UbiComp in the Home, *Proceedings of the Fifth International Conference on Ubiquitous Computing (Ubicomp 2003),* Springer-Verlag, pp. 208-226.
4. Crabtree, A., Hemmings, T., and Mariani, J., (2003) Informing the Development of Calendar Systems for Domestic Use, *Proceedings of ECSCW 2003,* Helsinki, Finland.
5. Dey, A., Abowd, G., and Salber, D., (2001) A Conceptual Framework and a Toolkit for Supporting the Rapid Prototyping of Context-Aware Applications, *in Human-Computer Interaction, Special Issue: Context-Aware Computing*, Volume 16, Numbers 2-4, pp. 97-166.
6. Dourish, P., (2001) *Where the Action Is: The Foundations of Embodied Interaction*, MIT Press.
7. Erickson, T., (2002) Some problems with the notion of context-aware computing, *Communications of the ACM,* Vol. 45(2), February 2002, pp. 102-104.
8. Edwards, K, and Grinter, R., (2001) At Home with Ubiquitous Computing: Seven Challenges, *Proceedings of the Third International Conference on Ubiquitous Computing (UbiComp 2001),* Lecture Notes in Computer Science, Vol. 2201, Springer-Verlag, Berlin, pp. 256-272.
9. Elliot, K., Neustaedter, C., and Greenberg, S., (2004) Time, Meaning, and Ownership: the Value of Location in the Home, Report 2004-761-26, Department of Computer Science, University of Calgary, Canada.
10. Fishkin, K., Moran, T., and Harrison, B., (1998) Embodied User Interfaces: Towards Invisible User Interfaces *Proceedings of the Conference on Engineering the Human-Computer Interface (EHCI'98),* Berlin: Springer.
11. Go, K., Carroll, J.M., and Imamiya, A., (2000) Familyware: Communicating with someone you love, *Proceedings of the IFIP HOIT Conference (HOIT 2000).*
12. Greenberg, S., (2001) Context as a Dynamic Construct, *in Human-Computer Interaction, Special Issue: Context-Aware Computing*, Volume 16, Numbers 2-4, pp. 257-268
13. Hindus, D., Mainwaring, S.D., Leduc, N., Hagström, A.E., and Bayley, O., (2001) Casablanca: Designing Social Communication Devices for the Home, *Proceedings of the Conference on Computer-Human Interaction (CHI 2001)*, ACM Press, pp. 325-332.
14. Hutchinson, H., Mackay, W., Westerlund, B., Bederson, B., Druin, A., Plaisant, C., Beaudouin-Lafon, M., Conversy, S., Evans, H., Hansen, H., Rouseel, N., Eiderback, B., Lindquist, S., and Sundblad, Y., (2003) Technology Probes: Inspiring Design for and with

Families, *Proceedings of the Conference on Computer-Human Interaction (CHI 2003)*, CHI Letters 5(1), ACM Press, pp. 17-25.

15. Intille, S., (2002) Designing a Home of the Future, *IEEE Pervasive Computing*, April-June, pp. 80-86.
16. Kidd, C., Orr, R., Abowd, G., Atkeson, C., Essa, I., MacIntyre, B., Mynatt, E., Starner, T., Newstetter, W., (1999) The Aware Home: A Living Laboratory for Ubiquitous Computing Research, *Proceedings of CoBuild 1999*, LNCS Vol. 1670, Springer-Verlag, Berlin, pp. 191-198.
17. Koile, K., Tollmar, K., Demirdjian, D., Shrobe, H., and Darrell, T., (2003) Activity Zones for Context-Aware Computing, *Proceedings of the Fifth International Conference on Ubiquitous Computing (Ubicomp 2003),* Springer-Verlag, pp. 90-106.
18. Mynatt, E., Rowan, J., Jacobs, A., Craighill, S., (2001) Digital Family Portraits: Supporting Peace of Mind for Extended Family Members, *Proceedings of the Conference on Computer-Human Interaction (CHI 2001)*, ACM Press, pp. 333-340.
19. Neustaedter, C., Elliot K., Tang, A., and Greenberg, S., (2004) Where are you and when are you coming home? Foundations of Interpersonal Awareness, Technical Report 2004-760-25, Department of Computer Science, University of Calgary, Canada.
20. Shafer, S., Brumitt, B., and Cadiz, JJ, (2001) Interaction Issues in Context-Aware Intelligent Environments, *in Human-Computer Interaction, Special Issue: Context-Aware Computing*, Volume 16, Numbers 2-4, pp. 363-378.
21. Siio, I., Rowan, J., and Mynatt, E., (2002) Peek-A-Drawer: Communication by Furniture, *in the Extended Abstracts of the Proceedings of CHI 2002,* Minneapolis, Minnesota, ACM Press, pp. 582-583.
22. Svanaes, D., (2001) Context-Aware Technology: A Phenomenological Perspective, *in Human-Computer Interaction, Special Issue: Context-Aware Computing*, Volume 16, Numbers 2-4, pp. 379-400.
23. Tollmar, K., and Persson, J., (2002) Understanding Remote Presence, *Proceedings of NordiCHI 2002,* Arhus, Denmark, ACM Press, pp. 41-49.
24. Venkatesh, A., (1996) Computers and Other Interactive Technologies for the Home, *Communications of the ACM,* Vol. 39(12), pp. 47-54.