Time, Meaning and Ownership: the Value of Location in the Home

Kathryn Elliot, Carman Neustaedter and Saul Greenberg
University of Calgary
2500 University Drive NW
Calgary, AB, Canada
[elliotk, carman, *or* saul]@cpsc.ucalgary.ca

ABSTRACT
Ubiquitous computing researchers suggest that technology embedded within the home can augment communication and coordination of home inhabitants. Our goal in this paper is to inform the design of effective home information systems, where we determine how households now manage communication and coordination. Through contextual interviews, we identify four types of communicative information found in homes: reminders and notes, awareness and scheduling, visual displays and alerts, and resource coordination. We found that these information types are created and understood by home inhabitants as a function of *contextual locations* within the home. We also found that the choice of location is highly nuanced. Location affects the *time* when others need to interact with that information, the *meaning* of that information and what needs to be done with it, and the *ownership:* who this information belongs to and who should receive it.

Author Keywords
Ubiquitous computing, home technologies.

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

INTRODUCTION
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 [3, 4]. This defines the new genres of ubiquitous and pervasive computing. As we move beyond the workplace setting, 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 [4, 7, 8]. The home 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 dwellers, 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 [9, 10, 11].

Our own focus is in *communication and coordination information for the home,* i.e., information that people use to communicate and coordinate with household members (including themselves) and with the outside world, where the home serves as the communication center. We include within this category any communication item used within the home or taken from the home into the outside world. For example, notes, lists, newsletters, schedules, calendars, voice mail, email, snail mail, and instant messages are all pieces of home communication information.

The vast majority of households already cope with large quantities of this information, mostly through a variety of tacit mechanisms. The technological opportunity is 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, e.g., [5, 9, 10, 11, 12, 13, 14]. However, without a great deal of care, inappropriate designs could lead to constant information overload [6] and ineffective uses.

What we really need is a deeper understanding of home inhabitants' current practices in how they organize, use and interact with this information. Several researchers have already explored various aspects of communication in the home, e.g., [1, 2]. In particular, Crabtree et al's study identifies "prime sites" in the home for introducing ubiquitous technology to support communication [2]. Our own goal is to provide design suggestions for how to better integrate communication technologies into the locations suggested by Crabtree et al. [2]. In particular, we investigate how people manage communication information using meta-data provided by *locations*, where we outline:

1. The types of communication information present in the home for which home information systems can be designed; and,
2. What the location of information tells people about that information, in order to better help them cope with and organize it.

Our paper method is an exploratory study—a set of contextual interviews—that identifies how people currently contend with communication information within their homes. This is described in the next section. Subsequent sections summarize our interpretation of our interviews, where we articulate the role locations have on information and interaction. These are illustrated by examples drawn from the study. We conclude with design recommendations for future home information systems.

METHODOLOGY

We used semi-structured contextual interviews to gain a thorough understanding of how households and individuals currently handle communication information in the home. This meant understanding what communication information is present and manipulated by inhabitants, and the role meta-data about each information source plays in its handling.

Participants

We recruited and interviewed twenty-nine people (16 female, 13 male) within the context of ten different households. Our participants included five teenagers, sixteen young-mid adults (ages 20 to 39) and eight middle-aged adults (ages 40 to 60). We did not interview children under the age of twelve.

We intentionally selected households to provide a broad range of household size, composition and demographic. Among the households we interviewed were roommates, common-law partners, divorced parents with shared custody, married parents with young children, working couples with teenagers and retired couples with adult children. Homes ranged in size from small one bedroom apartments to large houses, with a wide range in between. Participants were from a wide variety of backgrounds, including students, retirees, programmers and office administrators. Most participants were at least moderately technically inclined. Although we deliberately selected a broad range of households, we found many striking commonalities between them.

Method

We used a series of semi-structured interviews that took place in each household's home context. 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 photographed this information and these locations. For each information and/or location shown, we asked four key questions to help us discover how household members deal with this information.

1. ***What is it?*** What is this information about, what is it related to?
2. ***Whose is it?*** Do I need 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? What do *I* need to do with it?
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?

Our goal for an interview was to understand how a person answers these four questions given the type of communication information, its medium, and its location. Their answers suggest what meta-data people use that helps them decide how to handle the information they come across. Depending on what participants showed us and their responses, our interview questions then focused on understanding what kinds of information were present, why participants had chosen the various information locations, and when participants would typically access or interact with the information.

RESULTS

We analyzed interviews and observations using an open coding technique to draw out similarities and differences between participants and households. That is, for each observation we assigned it a code that stylized it, and used that code to mark any recurrence of it. Observations that did not fit were given a new code. We used the four key questions discussed in the Methodology introduction to characterize our coding labels. For example, for each type of information seen, we would code what it was, who it belonged to, and so on.

This open coding technique was intended to reveal similarities and differences between households and people. In general, we found that in spite of the diversity of our participant demographics and household compositions, there were many commonalities between them.

In the remaining sections of this paper we discuss our results. We caution that we do not provide full details of our results and our analysis, due to lack of space. Rather, we present our main findings and use actual examples drawn from our participants to illustrate what we saw. In particular, the next three sections outline the specific types of communication information found in the home, identify the media used to handle each type of communication information, and investigate the fundamental role that *locations* play and how they help people cope with communication information. For simplicity, from this point forward we use the terms *communication information* and *messages* interchangeably.

I. COMMUNICATION INFORMATION TYPES

We saw many similarities in the kinds of communication information present in the home, in spite of the diversity of homes, their layouts, and the people within them. These information types provide the first step in answering the

Figure 1a. **Figure 1b.** **Figure 1c.** **Figure 1d.** **Figure 1e.**

Figure 1. Information Types: Reminders & Notes, Awareness & Scheduling, Visual Displays and Resource Coordination.

question '*what is it?*'. Communication information in the home fell into one or more of four different categories.

1. ***Reminders and Notes*** are messages intended as memory triggers.
2. ***Awareness and Scheduling*** is information providing knowledge of the activities of others.
3. ***Visual Displays and Alerts*** is visual information that draws attention or is to be admired by others.
4. ***Resource Coordination*** is any information used to coordinate the sharing of a common resource.

These 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 (Reminders and Notes), and a way to coordinate sharing of duties (Resource Coordination). These four categories completely 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. Each category is discussed below in detail.

Reminders and Notes

The most common type of information present in the home is *Reminders and Notes*. This category includes anything intended as a memory trigger, e.g., hand written messages, phone messages, instant messages or emails. Homes had an average of twenty instances each of Reminders and Notes. We saw roughly equal occurrences of three sub-types of this information: *reminders* that reminded people about things they know but may forget, *notes* about new things that they need to know about, and *to-do* lists that contain a list of things that must be done.

This category is highly time-sensitive. The goal of messages in this category is to convey information at the right time, whether this time is related to the urgency of the message (e.g., an important phone note), or to its relevancy (e.g., needing to remember to return a DVD on your way to work).

An example of this category is visible in Figure 1a. Here, a mother has taken a phone message for her son, and has place this note on the son's computer monitor because there is some urgency to it. To foreshadow the role of locations, the mom knows that her son will see this, as his routine on coming home is to go to his computer to check his email.

Awareness and Scheduling

The second most common type of communication information present in homes is Awareness and Scheduling. *Awareness information* is used to maintain an understanding of the presence and activities of household members[1]. An example is using this information to know who is currently home, or at what time someone will be returning to the house. *Scheduling information* includes items such as one's calendar activities or time schedule. Both awareness and schedule information involve knowing details about the day-to-day routines of household members. Within the homes we studied, there was an average of nine instances per household of this kind of information, split fairly evenly between awareness and scheduling information.

This category of information is not as time sensitive as Reminders and Notes, but it is very important for the smooth functioning and micro-coordination of the household and the comfort of its inhabitants. The goal of messages in this category is to provide people with knowledge of the whereabouts and activities of others. An example we saw are families with children, where parents need to coordinate who drives the children to their various activities. Another example are latch-key children who need to know when their parents are arriving home, or conversely for parents when their child arrived home safely. A more mundane example is when dinner will be served. Awareness information is sometimes gathered peripherally (e.g., the presence or absence of cars or shoes), or is left explicitly as a note in a central common location (e.g., notes left on the kitchen table).

Figure 1b shows an example of a common scheduling artifact, a family calendar. On this calendar, events for members of the household are explicitly written down so

[1] A companion submission provides full details of an operational definition of interpersonal awareness.

that they are not missed or forgotten. Using the example above, this may include a ride schedule so parents know who needs to be picked up and where. Figure 1c shows an entryway to the house where guests leave their shoes, and how the presence or absence of shoes acts as an implicit message. Since members of this household enter through the garage, they know that if there are shoes in the front entrance way there must be guests in the home.

Visual Displays and Alerts

The third most common category is Visual Displays and Alerts. This information may be very important, so it needs to draw attention. Or, it may be just something to be noticed and admired. This includes some notes between family members (those that are intended to alert another to an event or a piece of information), as well as the display of items such as postcards, pictures, awards, or children's artwork.

The difference between this category and Reminders and Notes is that Visual Displays and Alerts are intended to be noticed visually, but may not have any time goals attached to them. The goal of this category of information is to attract attention at some point in time. Visual Displays and Alerts are to be noticed, but the actual point in time when they are noticed is of less importance.

As an example, Figure 1d shows a mantle in a family room containing pictures, birthday cards, awards and medals, as well as children's artwork and souvenirs. These are all pieces of infrequently updated information that the family wishes to display in a public location, where it attracts the attention and comments of both household members and guests.

Resource Coordination

The rest of the communication information we saw in the home falls into the fourth category, Resource Coordination. This category includes any information used to coordinate the sharing of a common resource. This includes contact information, financial data, and messages used to coordinate sharing of common household items and duties. For example, Resource Coordination items may include 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.

An example of this category is shown in Figure 1e. On the left side of the fridge door is a shopping list, while on the right side there is a receipt for the most recent grocery purchases. This information is used by two roommates to coordinate the sharing of groceries.

In summary, understanding the type of information is the first step to knowing how to handle a particular piece of information and answering the question '*what is it?'* As we will see, this is not enough, and other factors come into play to help people understand information and how it should be handled.

II. INFORMATION MEDIA

People choose many different kinds of media to communicate the four information types mentioned above. Figure 2 shows a small sample of the variety of these mediums, where we see a calendar, sticky notes, lists, newsletters from outside activities and voice mail (on the telephone in the right figure). We also saw many examples of electronic media such as email and instant messaging.

The most common medium we found for displaying information was the sticky note due to its versatility. They are small, inexpensive, just the right size for a quick note, and will stick to any surface, horizontal or vertical. Participants found sticky notes especially useful for Reminders and Notes, and for Visual Displays and Alerts because of the ease of attaching them to desired surface.

Voice, text messaging and video (over instant messaging IM and the phone) provide some Awareness and Scheduling information. A phone call or text message from Mom says she'll be home in time for dinner. A couple with a child located in another country used IM's voice and video capabilities to stay in touch. Several of our participant households open a text editor on a shared computer, type a message, and then leave the page open so the next person will see it right away as they sit down at the computer. Household artifacts are yet another media form, where awareness is obtained peripherally through their presence or absence, e.g., shoes, cars and bikes.

Households often contain a common paper calendar where everyone marks down their appointments and other critical times (this contrasts to personally held electronic or paper calendars). Other schedules are usually paper printouts, brought home from work or school. These contribute to information for Awareness and Scheduling.

When people have a choice of mediums to use, it is not always the information type that determines the medium selected for a particular message. Instead the selection of medium is based on who needs to see the information, the convenience and comfort level of the medium and whether

Figure 2. Diverse information media are used in the home.

or not the information needs to leave the home. The placement of the information medium is also a large part of this choice. That is, the affordances of where the message needs to be will help determine the media used. For instance, if a note needs to be left at the family computer, sticky notes that can go right on the monitor are often used.

The type of information medium by itself rarely helps household members answer the questions necessary for them to handle a particular piece of information. For example, the fact that a message is on a sticky note does not tell people who it is for, what they need to do with it, when they need to interact with it or even what kind of message it is. In general, the only question that the medium choice can answer is '*what is the information?'* e.g., the choice of a calendar for Scheduling, or the choice of a photo for Visual Display. And even here, there is frequently only a partial answer provided. The answer to these questions, and the ability to cope quickly with the information, is provided by richer means—*locations*—as we will describe next.

III. LOCATIONS

Every household we looked at has a set of key locations that home inhabitants use for displaying, interacting, organizing and coping with communication information. Locations provide people with an important set of meta-data, including time information (e.g., urgency), ownership information (e.g., who the message is for) and richer meaning (e.g., related information or events). Locations are what enable people to answer the questions necessary for handling each piece of information: *whose is it, what needs to be done with it,* and *when do I/others need to interact with it.*

We first describe how locations for information are initially selected to provide answers to these questions. We then describe the ways these chosen locations afford time, meaning and ownership to the information placed there.

How Locations are Selected

We consider 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 locations per household appears to be determined by two separate factors. The first is simply the size of the house: the smallest home we studied had the fewest locations and the largest had the most locations. While we found some exceptions to this rule, in general, the larger the house, the more locations present. The second factor is the number of separate adult lives present 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, we found that 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. We also found that because couples typically have very entwined lives, they need fewer locations because they share them. Thus, a couple tends to have fewer locations than that of two unmarried friends or roommates.

The number and placement of these locations is a shared household understanding that develops over time. To illustrate, one of our participant households was a group of roommates who had been living together for only a few weeks. While they already had a good understanding of places for their own information, the shared locations were not yet well understood, as their meaning and use of locations evolved over time.

Through typical everyday routines, households implicitly select these 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.

Location Attributes and Proximity

The attributes of the location influence what information is placed there. That is, what kinds of information is left or placed in any given location depends heavily on the location's attributes. For instance, it would make very little sense to organize school handouts by pinning them up on the wall in the bedroom. Information would not be at hand when it was needed, and important events or letters might get missed. It is much more likely that these handouts will be stacked in piles on the kitchen counter, because it's flat, and they can be moved around easily. As a common, frequently visited place, the counter is a location where everyone who needs this information can get at it.

There is also the issue of relevance—information related to something needs to be near it, so the media will be chosen to adapt to the location. Phone messages will often be left on sticky notes near the wall phone; shopping lists on the fridge will be magnetic, etc. *Places in the home will be repurposed as information locations to meet people's need for organization.*

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 that information might be missed. Instead, it is added to the already busy kitchen counter. While it takes up much needed space, competes for attention, and gets in the way, it is more easily accessed. A second example would be

putting the DVD that needs to be returned on the first stair leading down to the entryway, even though it might be less hazardous to leave it by the TV. *Location has great value in terms of providing organization and relevance that it overrides more practical considerations.*

Pathways and Clusters

Information locations tend to be placed in various ways throughout the home. People rely on their knowledge of routines (their own and those of others) as well as the placement of main traffic paths and common areas in the house to find suitable places for information.

Pathways and routines. Information locations tend to group themselves along pathways through the house, 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 knowing the routines of household members—what they do when they come home, where they go, where they leave things like keys or purses, etc. For example, in one of our households, the teenage son enters through the front door, passes through the kitchen, and then goes down to the basement. For this reason, notes for him are left 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 most logical place for this information. *Households use their knowledge of routines and pathways to select information placement.*

Clusters. 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 *clusters*. For example, if the kitchen counter is used to organize newsletters, etc., other locations like the family calendar will usually be nearby. Clusters are most often present in common areas of the house—the kitchen, family room, entrance way, etc.

Neighborhoods. Communication media such as phones and computers also seem to attract communication information. Since these areas are less portable, information typically comes to them. And since locations group together as we described above, clusters will often form around these areas. We call these groupings *neighborhoods*. For example, phone messages usually go next to the phone, for obvious reasons. However, calendars are also usually near the phone, so that people can check their schedules when making plans. Other types of information may be needed near the calendar. This creates an information neighborhood around the phone. *Information locations tend to group themselves so that relevant information is nearby.*

The above location attributes and groupings are simply how people initially choose locations to communicate with members of their household, where these locations become part of the household's shared language. Next, we will see that this choice of location actually adds information to each message, where it provides meta-data regarding *time, meaning* and *ownership*.

Figure 3. Urgent messages from a mother to her teenage son.

Time

One of the main ways locations add information is in timing. Time attributes for a piece of information, e.g., 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 should 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 would use their knowledge of the routines of themselves and others to know where to put information so that it would be seen when it was needed in a timely 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, in one of our participant households, messages and notes from a mother to her teenage son were usually left near the computer upstairs, where it would be seen at some point over the course of the day. However, as we see in Figure 3, when a note was particularly important she would put it directly on the TV screen, as she knew her son would surely see it as soon as he returned home.

This information also works for recipients of information. Household members know when there may be messages for them at certain locations. 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.

Figure 4. Envelopes to be mailed are placed with keys.

Reminders are another example of this quality. The placement of a piece of information is very frequently used to create a reminder at the right time. For example, Figure 4 shows how one household member leaves things that need to be taken to the mailbox with his wallet and keys, so that he sees them when he picks up his keys to leave in the morning. This type of reminder, done by leaving things where they will be noticed at the right time, was very common in all the households we studied. *Locations provide a vital means for people to convey time-related relevance and urgency.*

Information Dynamics

Information will change location over time as its dynamics change. This includes relevance to other messages, whether or not actions associated with the 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 found 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 move it to a third location for storage, a filing cabinet for example. This is true of a lot of 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, the left of Figure 5 shows one of the households we studied where phone messages are left on sticky notes on the outside of a cupboard door above the main household phone. Once messages have been seen and returned, some are thrown out, but those that have contact information on them that household members do not wish to lose are placed on the inside of the cupboard door (Figure 5 right side) for a kind of longer term archive. Members of the household know 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.*

Figure 5. Left: Current Messages. Right: Stored Messages.

Meaning

The second major way in which locations provide meta-data for communication information is by attaching richer meaning to the information. A piece of information in one location of the home may mean something completely different than the same piece of information in another area. This allows people to answer two of our questions: *what is this information* and *what needs to be done with it.*

While the information content may answer these questions as well, it would take a great deal of time to go through each message every time a piece of information is needed. Locations provide meta-data that helps people quickly and correctly answer these two questions. In turn, this allows people to more easily cope with messages.

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. 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 that they are expected to do something 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 that person can see it as they leave. A message may be a request for action from someone else. For example, a child may place a school notice for their parent to sign on the parent's desk. *The location of information implies intended actions.*

Organization

Information can quickly become overwhelming if dealt with individually. We found that people tend to use locations to support schemes for organizing their information. These schemes are usually devised by one member of the household but then followed by all. For example, in one of our participant homes, all school, PTA and band handouts were organized into different piles by subject on the kitchen counter. Those that were for immediately upcoming events were moved to the top of the microwave. In this way, not only was information organized by category, but it also provided relevant meta-

data (in this case, that the event was upcoming). *Locations are used to organize information by relevant means.*

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 was also frequently cited as a way of knowing who was around, including whether or not guests were there.

Figure 6 shows how one of the participant households had a particularly rich system for handling awareness information. Each member of the household would wear different colored 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 when the wearer was not in, or at the foot of the stairs when they were upstairs in the carpeted area of the home. In this way, family members always knew who was home, and their general location in the house. *The presence of an object in a routine location can provide information to household members.*

Figure 6. These slippers indicate presence and location.

Ownership

Finally, location is used 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 question *whose information is this.*

Responsibility

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 ownership (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 take action on. The ownership of the space implies the ownership of the information and who assumes responsibility for it.

We found four main subtypes of location ownership within homes: public spaces, public subset spaces, personal spaces, and private spaces. *Public spaces* are those owned by everyone in the home. For example, the main house phone or the fridge door are usually considered public spaces, and messages affixed or near it may be for anyone. Figure 7a 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 they share, but that do not belong to others in the home. Figure 7b shows a desk from one of our homes. Here, the parents leave a shared calendar that their two adult sons do not look at, write in or otherwise interact with. The sons know that this calendar is just for their parents because it is located in their parents' space.

The other two types of spaces belong to individuals. Information within these spaces is understood to be for the owner. The first type is *personal spaces*. These are spaces intended for only one individual but that are still publicly visible. These could be the door to a bedroom, a placemat at the kitchen table, etc. Other members of the house will leave information in these places for the owner, and the owner will leave information there for themselves as well. Figure 7c shows one person's 'private placemat'. It contains items placed there by that person for their own use. Yet it is also publicly accessible to others for leaving things for this person. Yet it is known by other household members as that particular person's space.

The last kind of location is *private spaces*. These are spaces intended for only one individual and are not publicly visible or usable by others. These spaces may include day timers, purses, etc. The information left in private spaces is usually personal reminders, personal scheduling and contact information. People typically do not want others to see information in these locations. For example, Figure 7d shows the personal agenda of one household member that she does not want others to view.

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 or information action responsibility.*

Visibility and Privacy

The visibility of the different locations within the home implies ownership and privacy. Information that household members don't necessarily want others to see will be placed in locations that are less visible and more private. Information to be shared with others (e.g., awards, pictures, messages to all) is put in the highly visible and publicly

Figure 7a. Public space

Figure 7b. Public subset space

Figure 7c. Personal space

Figure 7d. Private space

Figure 7. Location Ownership

accessible locations. Household members use this in order to protect their own privacy and to protect that of others when it is needed. They also use this knowledge to know when information has been placed somewhere for sharing, or when this information is more sensitive. *The visibility of the location of a piece of information implies its privacy level.*

DESIGN IMPLICATIONS

Our study found that communication in the home involves a rich and highly nuanced use of information, media, and locations. All findings have implications for the design of ubiquitous or context-aware technologies for augmenting communication and coordination in the home.

First, we identified several types of communication information used in the home along with their frequency. These types can help designers identify areas where the most value could be received from new systems, as well as what kinds of information these new systems could integrate within them. Second, knowing the different media people currently use for messaging will inform those design attributes that a new implementation should have if it is to best support the information. Third, we found that locations are a vital part of how people cope with the large amounts of communication information present in each home. Regardless of the media and the information, the placement of a piece of information in a location provides household members with time, meaning and ownership information, allowing them to quickly answer the four questions necessary for easily handling a given piece of information.

From this study, we do know what won't work. Having all information available through some kind of monolithic computer application accessed through a conventional display misses all the nuances of location placement, and suffers from information overload. People will not know where the information is, will not know what they have to deal with at the moment, and will not be reminded at appropriate times. Our current digital environments will not work well because of the basic invisibility of digital information. For example, the virtual desktops and filing systems on a personal computer 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. Similarly, the current email metaphor shows messages out of context, with little timing information, and with high overhead for creating, reading and managing these messages. While both can contain the raw information, neither has the meta-data we saw in home communication messages.

We do know that our design solution must use location. Locations are used on such a large scale within the home that we cannot ignore it. 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 interacting with it and providing it with context and value. 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. Since home inhabitants add meaning when they select the locations over time, these locations cannot be hardwired into the home except in special cases (e.g., the fridge door or the telephone as a likely neighborhood).

Obviously 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 more resistant to change and to technology. If locations are not used within the design of

these new systems, designers need to consider how the meta-data provided by locations can be conveyed or captured by some alternative means.

Given the above 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, and its ability to be conveniently placed at any given location. Yet opportunities abound. When asked, our participants could all see areas in home communication where they would like to see technology. They suggested everything from an online family calendar, to a system that would announce messages as they walked in the door. This is currently a mostly unexplored niche for developing new applications. We envision special purpose ambient information appliances that can be located and relocated in opportune home locations. We envision small wireless displays, perhaps with a writeable surface and of different sizes that can be placed anywhere. Perhaps they have a magnetic or sticky backing. We envision more use of sound to inform people or to attract attention. We envision people being able to create information from outside the home, but have it appear within the home in the appropriate location and context.

CONCLUSION

We presented a study aimed at understanding how people currently handle communication information in the home. We offer two main research contributions from the results of this study. First, we identified four types of communication information in the home, as well as the media and the media attributes currently used to convey that information. Second, we articulate the vital role that location plays in providing meta-data to household members that allow them to easily decide how to handle communication information. This meta-data, related to time, meaning and ownership, allows people to deal with the vast quantities of information present in the home.

Our results are significant for they offer designers and practitioners compelling implications for the design of future home information systems. Namely 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. While we do not yet offer specific design ideas, we have laid a foundation of knowledge which clearly suggests what will not work and should inspire methods that do work.

Our own future research directions will now focus on using our study results to design ambient and interactive devices to support communication information in the home.

ACKNOWLEDGMENTS

We thank TRLabs, Alberta Ingenuity, iCore and NSERC for funding this work.

REFERENCES

1. Crabtree, A., Hemmings, T., and Mariani, J., Informing the Development of Calendar Systems for Domestic Use. In *Proc. ECSCW 2003,* Helsinki, Finland, (2003).
2. Crabtree, A., Rodden, T., Hemmings, T. and Benford S. Finding a Place for UbiComp in the Home. In *Proc. Ubicomp 2003*. Springer-Verlag (2001), 208-226.
3. Dourish, P., Where the Action Is: The Foundations of Embodied Interaction. MIT Press (2001).
4. Edwards, W.K. and Grinter, R.E.. At Home with Ubiquitous Computing: Seven Challenges. (2001) In *Proc. UbiComp 2001*. Springer-Verlag (2001), 256-272.
5. Hindus, D., Mainwaring, S.D., Leduc, N., Hagström, A.E., and Bayley, O., Casablanca: Designing Social Communication Devices for the Home. In *Proc. CHI 2001*, ACM Press (2001), 325-332.
6. Intille, S.S.. Change Blind Information Display for Ubiquitous Computing Environments. In *Proc. UbiComp 2002*. ACM Press (2002).
7. Intille, S., Designing a Home of the Future, *IEEE Pervasive Computing*, April-June 2002, 80-86.
8. Kidd, C., Orr, R., Abowd, G., Atkeson, C., Essa, I., MacIntyre, B., Mynatt, E., Starner, T., Newstetter, W., The Aware Home: A Living Laboratory for Ubiquitous Computing Research. In *Proc. CoBuild 1999*, LNCS, Vol. 1670, Springer-Verlag, Berlin (1999), 191-198.
9. Kim, S., Chung, A., Ok, J., Myung, I., Kang, H., Woo, J. and Kim, M.. Communication Enhancer: Appliances for Better Communication in a family. In *Personal and Ubiquitous Computing*, Vol. 8 (July 2004). 221-226.
10. Kim, S, Kim, M, Park, S. Jin, Y. and Choi, W. Gate Reminder: A Design Case of a Smart Reminder. In *Proc. DIS 2004.* ACM Press (2004), 81-90.
11. Mynatt, E., Rowan, J., Jacobs, A., Craighill, S., Digital Family Portraits: Supporting Peace of Mind for Extended Family Members. In *Proc. CHI 2001*, CHI Letters 3(1), ACM Press (2001), 333-340.
12. Nagel, K, Kidd, C., O'Connell, T., Dey, A., and Abowd, G., The Family Intercom: Developing a Context-Aware Audio Communication System. In *Proc. Ubicomp 2001,* Springer-Verlag (2001), 176-183.
13. Park, S., Won, S. Lee, J. Kim, S. Smart Home: Digitally Engineered Domestic Life. In *Personal and Ubiquitous Computing*, Vol. 7 (July 2003). 189-196.
14. Venkatesh, A., Computers and Other Interactive Technologies for the Home. In *Communications of the ACM,* Vol. 39(12). ACM Press (1996), 47-54.

Contributions and Benefits Statement:

Describes communication and coordination information in the home and how it is managed through contextual locations. Results guide the design of home information systems embedded in domestic environments.