Sticky Spots and Flower Pots: Two Case Studies in Location-Based Home Technology Design

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Abstract. Ethnographic studies of domestic environments have shown the fundamental role that *contextual locations* play in helping people understand and manage communication information. Yet it is not clear how this knowledge can be applied to the design of home technologies to effectively support the routines of home inhabitants. For this reason, we present two case studies in home technology design that use the results of previous ethnographic studies on domestic locations to motivate the designs and to make them location-based. The first case is StickySpots – a *location-based messaging system* that allows household members to send short digital messages to various places in their home. The second case is *location-dependant information appliances* – a pair of physical ambient displays that show different information depending on where they are placed within the home. We reflect on these case studies to motivate and discuss an initial set of guidelines for location-based design in the home.

1 Introduction

Researchers have suggested that the technology enhanced home – the smart home – could have many benefits for its inhabitants. [11, 13, 16] These include improved time management, better connectedness to loved ones and extended entertainment options. The challenge for researchers and designers is to build this new technology so that it fits into the natural routines and patterns of the home [6].

Many researchers have begun looking at how information is currently used in the home, e.g. [5, 12, 21]. We do this in order to understand current uses and patterns so that we can recognize opportunities for technology and design systems and devices that fit into people's existing home lives to enhance them in appropriate and interesting ways.

In particular, this paper presents two case studies as examples of how the results of ethnographic studies of home routines can be applied in technology design practice. We first summarize these past findings, highlighting the concept of *contextual locations* [9] and how they are a part of information management in the home. Following that, we present our first design case study – the *StickySpots* messaging system – and discuss how it uses the understanding gained in the study to both articulate the problem and to develop a solution. We reflect on this design, where we derive a potential

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Figure 1: Examples of communication information in the home

set of design guidelines for using locations in home technology design. We then present our second case study, *location-dependant information appliances*, which leverages the results of domestic studies in a different way. We conclude with future directions our work will take.

2 Motivation: The Value of Location in the Home

Our specific interest is in domestic communication information, which we define to be any item in the home that is used to communicate with other members of the household, or with the outside world, e.g. notes, messages, lists, newsletters, schedules, calendars, voice mail, email, letters, pictures, etc. What is perhaps surprising is that the home has not yet embraced computer technology. Even though information display and management is something technology generally does very well, existing technology does relatively little in terms of helping us with the day to day "business" of running the home, and of managing all the information within it.

There is considerable information of this kind in every home. Many homes have kitchen counters and communal desks covered with papers. Bulletin boards overflow with items. Special purpose items include continuously updated calendars and schedules, along with phone messages, letters, bills, pictures, lists and sticky notes. Figure 1 shows three real world examples [9].

Our current work is primarily based on a prior study of home information management [9]. This prior study was exploratory and involved interviewing ten households about the communication information they used in their homes and how they managed it. Participants were asked to show the information in their homes. It was then photographed in situ, and participants were interviewed about it. Participant households were chosen to be deliberately varied in terms of demographics, household composition and home size.

Even though the study participants were diverse, they all had strong commonalities in how they managed information in their homes, and in the types of information present. When household members were asked about pieces of information in their homes, they would provide a four part answer. They would say *what* the piece of information was, *who* it belonged to, *what action* they needed to do with it, and *when* they needed to see it. For example a typical answer would be "Well, that's a phone message *(what)* for my mom *(who)* and she needs to call them back right away *(what action),* so she needs to see it as soon as she comes home *(when)*."

Information Types. When participants explained *what* a certain message was, these explanations fell into five general types of information, categorized by how the information is used or its intended use.

1. **Memory Triggers** are intended or used as time sensitive memory support. This includes reminders, to-do lists, and notes that alert household members to critical information – e.g. food containing allergens, or light switches that should not be flipped. This is the most common type of information present in the home.
2. **Member Awareness** information provides knowledge of the activities and whereabouts of household members. This information is sometimes left explicitly – like calendars or notes, but can also be understood implicitly, from the presence or absence of keys, bags, cars or shoes.
3. **Exhibits** are to be shared, noticed or admired. These are infrequently updated. They include items such as cards, pictures, awards, children's artwork and travel souvenirs.
4. **Notices** provide household members with information about activities or people outside the home. This includes newsletters, phone messages, school notices, etc.
5. **Resource Coordination** information is used to coordinate the sharing of common household resources. This includes things like grocery lists, receipts, bills and chore charts.

These information types, while not explicitly listed in other studies, are reflected in the examples used within, [e.g. 5, 12, 21]. They help people know *what* the information is. However, they don't tell people who the message is for, what should be done with it, or when it should be seen. This meta-data, what people really use to manage information in their homes, is gathered though a much richer means**.**

The Value of Location. When participants were asked how they knew who a piece of information was for, what needed to be done with it, or when it should be seen, the answer was almost always some variation on "Because it is *there*." – Because it's on the door, because it's in her spot, because it's on the fridge. The *location* was what provided household members with the context they needed to understand, filter and manage the information in their homes.

Each of these locations has meaning to the household members. Placing something on the fridge, for instance, tells household members something very different than placing it in the entranceway. This meaning has developed over time as a shared household understanding. Household members know each others' routines and pathways through the home and use this understanding to place information so that it becomes a part of their home context. So to the home inhabitants, the notes on the door, the pages on the bulletin board in the kitchen, and the keys are on the rack all have specific meanings. To outsiders, it may just look like a mess.

The role of space in the home is also examined and discussed in several other ethnographic studies. Crabtree et al. [5] discuss how space is interwoven with action and activities in the home. They present three types of information places in the home, categorized by what actions take place there. Their work looks at how information moves throughout the home as people see it, share it and work with it. Taylor and

Swan [21] talk about similar concepts in terms of how information design and placement create 'organizing systems' in the home, and how these organizing systems shape household routines and social interactions. Harper et al. [12] examines how the affordances of paper-mail, including the ability to be placed anywhere in the home, have made it hard to completely replace with email. They discuss how paper-mail is broadcast and "moved around the house in a fashion that supports the organization of the family." [12] The common theme in this work 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.

Time, Ownership and Awareness. The study we are focusing on calls these places *Contextual Locations*. [9] The participant homes contained on average 15 such locations, though it ranged from 4 to 23. Figure 2 shows six of the more public locations from one participant household [9], including their entranceway, a bulletin board and counter in the kitchen, the fridge door, the living room mantle, a key rack and their home office.

These Contextual Locations allow information to be interwoven with not only action and activities, as described by Crabtree et al. [5], but also with *time, ownership and awareness.* Household members, because of their understating of each others' routines and interactions, know *who* a message is for, what *actions* need to be taken on it, and *when* they need to see it by the context of *where* the message is placed. This location meta-data is a big part of how people manage the information in their homes.

1. **Time** information gives household members a sense of the urgency of the information and a sense of the dynamics or status. These locations are chosen for

Fig. 2: sample Contextual Locations, containing a wide variety of communication information.

when they will be seen. A frequent example was the placement of items by the entrance to the home. This could include DVDs to be returned, notices to be taken to school or cheques to be mailed. Placing them by the front door ensured that they would be seen at the right time – when leaving – so they wouldn't be forgotten. A second example includes placing new phone messages in a different location from those that have been seen already, so that household members know what needs their attention.

2. **Ownership** is how people know who the message belongs to, who is responsible for anything that needs to be done with it, and whether or not they need to pay attention to it. These locations are chosen for *who* they are associated with. The fridge door is a common example of a public location – the household knows that anything placed there is for everyone to see. Placemats at the table or doorways to bedrooms are personal spaces – messages placed there are for one person only, and other household members don't need to worry about them. People often place items in such personal locations as requests for actions, as in a child placing a notice to be signed on his mother's placemat so she'll see and sign it at breakfast. In this way, people also know what *actions* need to be taken.
3. **Awareness** information is more subtle. It gives inhabitants a way to monitor and support each other, and lets them know what others are up to. An example of this is a wife seeing that her husband has not yet paid the bills because they're still in his pile on the counter. She knows he's been busy so she takes on the job of paying them herself. He is then aware she has done this because the bills have been moved to the computer.

This context, combined with information types, is what enables people to provide the four part answer we discussed earlier. This is a very large part of how information is managed in the home. In the rest of this paper, we use these observations and results, along with the related work, to help create *location-based designs*. 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 as case studies that illustrate how our results can be used in future home technology design.

3 Case Study 1: StickySpots

One way in which ethnographic findings can be used is to articulate problems that might be addressed with technology. Elliot et al. [9] saw that considerable 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.

Figure 3: Short messages are left in a variety of locations in the home.

Figure 3 shows several examples of these types of messages from participant households. What is typical – and critical – in these examples is that messages are left in a wide assortment of 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 3). She knows he won't miss it there because the 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.*

Messaging is also one of the most popular computing applications, both outside the home and within it. Examples include instant messaging, 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. 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 new messaging system specifically for the home is a natural choice for domestic technology design.

3.1 Location-based Messaging

The understanding gained from ethnographic studies can also be used to suggest the direction of the design solution. As described in the previous section, we saw that the location of messages in the home is chosen by household members to give the message all kinds of 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 messaging design solution should therefore be *location-based* if it is to be successful.

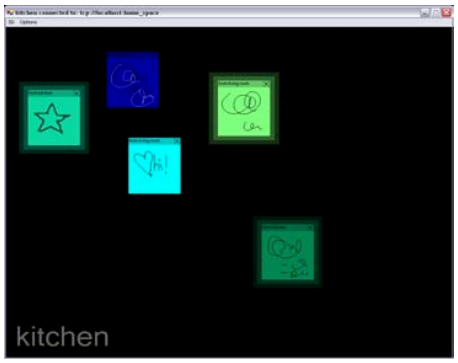

Fig. 4: StickySpots – location-based messaging

3.2 The StickySpots Message System

Figure 4 shows a screenshot from StickySpots – the *location-based messaging system* we have developed. StickySpots sends messages primarily to locations rather than to people. These locations are specific spots in the home, as it is intended to be used on a network of displays incorporated into 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. Displays have decreased significantly in price, and with the continued development of home technology, it is not unreasonable to imagine that a future smart home would have many networked displays – even touch sensitive ones – in a wide variety of locations. Each display in the home is signed in to a central

Fig. 5: Notes sent with StickySpots, a prototype location-based messaging system

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*.

System Description. StickySpots is designed to look similar to a bulletin board. It allows household members to create simple handwritten notes, 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 [14] 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.

Messages can be sent to locations in two different ways. First, a message can be sent to the actual location, e.g. the living room TV. Senders create a new note, and then select a destination. 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 urgency or ownership. New notes have a soft halo to indicate their status (fig. 5b) so household members can easily see changes.

Touching the note shows when it was sent and where from (fig. 5c). Notes can be opened to a larger size by double tapping, and replies can be easily added and sent. Web links and small images can also be added. Notes appear in a random arrangement on the display, but can then be dragged around as desired.

The second way that messages can be sent to a location is to send them to a person as a sort of location proxy. Messages sent to people can be shown on any display. People can either sign in explicitly through a simple dialog or can be sensed by the system. We use RFID tags small enough to be attached to a watch band and RFID readers in the display locations to detect people, as shown in figure 6. When a person is detected, all messages sent to that person show up on the nearest display in a

Fig.6: RFID tags, small enough to be worn, identify people, and show them personal messages.

smaller grey side window, as on the far right of figure 6. 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.

Implementation. StickySpots was built using three prototyping toolkits. GroupLab.Networking [2] enables the easy creation of a server to share information between locations. The notes are delivered as multimedia photos using the Collabrary [3], and the system uses Phidget [10] RFID readers to identify people.

3.3 Discussion

If we go back 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 then 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. Anne also 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. Dave will therefore see the note at the right time and in the right context, and remember to put the casserole in the oven.

StickySpots adds value in that Anne can send the message right from the kitchen as she's cooking or even from the office the next day. The fact that she can also send the note to Dave and have the system sense where he is, allows for more flexible messaging choices. In addition, Anne's message could also 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 so he knows when to take it out of the oven.

Extensions. We could easily extend StickySpots to provide even more value, including allowing rich text messages along with handwritten ones, and providing support for sending messages to and from mobile devices, such as phones and PDAs. We would like to add the ability for users to create two additional kinds of messages: timed reminders that would show up at the selected location at some specific preset time, and automated messages that would be sent to a preset location when a web page or other information is updated. Beyond this, we want to provide support to send messages to other kinds of displays, including small text LCDs, physical displays, and audio displays since we believe future homes will contain a wide variety of information display types. However, our next step is to set up, use and evaluate StickySpots in an actual home, which we hope will reveal new ways in which the system can be used, improved and extended.

Related Work. There are existing location-based messaging systems in the related research. One example is HomeNote, a home messaging system from MSR Cambridge [19]. HomeNote allows users to send a text message from their mobile phones

to a display set up in a public area of their home. It also lets household members and guests scribble handwritten messages on the display. Though not targeted specifically for the home, Place-Its [20] are a second example of using location in messaging. This is a system that 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 – the home as a single location unit.

The study results, especially Contextual Locations, show that while it is important to be able to send messages to macro locations like the home as a whole, there is also great value in having messages in 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 is a different way of thinking about location that came out of the study results, and it provides new opportunities to use context and routines within the home. As a consequence, 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.

Reflection. Location-based messaging is only one example of how we can use study results to articulate areas in home information management that could benefit from technology. The list of information types alone provides a good starting point when looking at what technology people would use and appreciate in their homes. For example, Memory Triggers, especially 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 [15] is a prototype system that lets reminders be sent to the home's entrance way, and then displays them as people 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 would be to allow calendar reminders to be sent to StickySpots. So when setting a reminder on your calendar, you would not only specify a time, but also a location where you would like the reminder to appear.

Design Guidelines In terms of suggesting directions for design solutions, we have created a "prototype" set of design guidelines that we feel could be a starting point for developing location-based design heuristics, which could then be used for both design and for evaluation. We have four prototype guidelines, presented below.

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, with increased value, and with interaction opportunities. [9, 5]. They should use the fact that location will provide contextual time (urgency, status and relevance), ownership (personal, public, privacy level) and awareness (monitoring, presence/absence) information. These designs should either exploit this natural meta-data or, if it is not possible to do so, replace it in some way.

2. Add Value: Location-based designs should add virtual value to existing household spaces and organizational systems. They should provide more power when compared to paper or other traditional workarounds. This could include adding search, sort or networking capabilities; providing dynamically updating information, adding multimedia, or integrating further interaction opportunities. These designs should do this without requiring the user to return to the PC, so that the extra value is available where it is naturally a part of the household ecology.

3. Be Specific: Location-based designs should use location in a micro rather than a macro sense. They should think about locations specifically, e.g. the kitchen table, the mantle, the front door, etc. rather than simply the encompassing macro of 'home', as this is how household members 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. They should not force routine changes and should allow for household individuality – they need to fit within existing systems while still providing extended value and opportunities. The underlying system should also be flexible enough to allow for change, as households rearrange, grow and evolve. This flexibility is an important part of enabling new kinds of technology in the home [7, 13] 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.

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.

4 Case Study 2: Flexible Ambient Displays

Another 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 routines and patterns of the household. In this next case study I will discuss two existing ambient displays and show how they can be repurposed by location to provide additional value in the home.

4.1 Flexible Ambient Displays

We have taken an existing set of physical devices called Flexible Ambient Displays [8]. Flexible Ambient Displays are designed to meet two specific design goals: to allow for flexible information sources and to provide a smooth transition from awareness into interaction. These two goals suggest that these displays could have value in a domestic environment.

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 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.

Fig. 7: the Ambient Garden and the Glow Lamp

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 [14]. 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.

There are two specific devices that we will talk about here, as pictured in figure 7. The first is the Ambient Garden – a small box containing felt flowers with red or green lights in the centres. The second is the Glow Lamp – a small lamp with a shade that rotates to show different coloured panels. There is a touch sensor under the front flower of the Garden, and in the indicator arrow on the Lamp. Both devices are built using Phidgets [10].

As an example of how these displays could be used, meet Bob. When Bob gets up in the morning, he goes down to his computer and checks the weather forecast to decide what to wear. Then, while eating breakfast, he listens for the traffic report on the radio, so he can avoid any jams. Later, in the evening while watching TV, he turns the volume up really loud on his PC in his home office, so that he can hear the audio alert from his instant messaging program when someone signs in. Whenever he hears the alert, he gets up to check to see if it's his fiancée Ellen, who is going to school in England. Bob has an Ambient Garden attached to his home computer. The device is flexible, so he can show a weather forecast, the traffic conditions for his commute, or Ellen's IM status. However, he needs to change the information source manually (by closing one application and starting another), so mostly he just leaves it on the weather forecast, so he can see what is coming at a glance. Occasionally, when he plays video games on his computer in the evenings, he changes it to show Ellen's IM status. Although the display still has value for Bob, it doesn't make use of his natural routines and locations, so he uses it in a limited way.

4.2 Location-dependant Information Appliances

Contextual Locations tell us that people use location to provide context to the information placed within them. While Flexible Ambient Displays have potential for the home, they do not use location in any way, which limits their integration.

Since the 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. Household members, like Bob, are interested in different information at different times during the day, and would like to have that information in the right places so that they can see it during their daily routines. If we allow our displays to be easily moved, we can display information in the right context by allowing it to be in the right location. The information then benefits from the valuable, even indispensable, context that these locations provide.

System Description. We have taken our Flexible Ambient Displays and extended them to be used as *location-dependant information appliances*. We have taken the Ambient Garden and the Glow Lamp and added Phidget RFID readers [10] into them. Currently, these prototype displays are connected to a tablet PC so they can be easily moved, though in a final design the computing elements would be built into the appliances themselves.

We then placed small RFID tags in various places in the home. The tags are smaller than a quarter, and can be placed anywhere and easily concealed. We created a simple management program to assign location tags to any application that displays information on the flexible ambient displays. Thus a location becomes virtually connected to the information that is desired there.

As mentioned, the design of the flexible ambient displays makes it relatively easy to create new programs, though it does still require programming skills. Our own existing demonstration programs display a weather forecast, an IM contact's status, the contents of an email inbox, and even motion as sensed by a webcam.

The assignment of tags to locations and to display applications is very straight forward, as shown in figure 8. The user starts up the management program. When the new tag is shown to the device's RFID reader (as in fig. 8a), it is recognized as unknown. The user can then name the tag's location, describe the information to be displayed, and select the application to run in that location (fig. 8b). Then the user conceals the tag in the desired location (e.g. fig. 8c) When that tag, now known, is read by the ambient device, the tag management program stops any display application that may be running, and starts up the one assigned to that location.

The tag management program shows a list of all the tagged locations along with what application is run there (as in fig. 8d). These can be edited by double clicking. 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).

The fact that the devices contain touch sensors mean that more detail is available

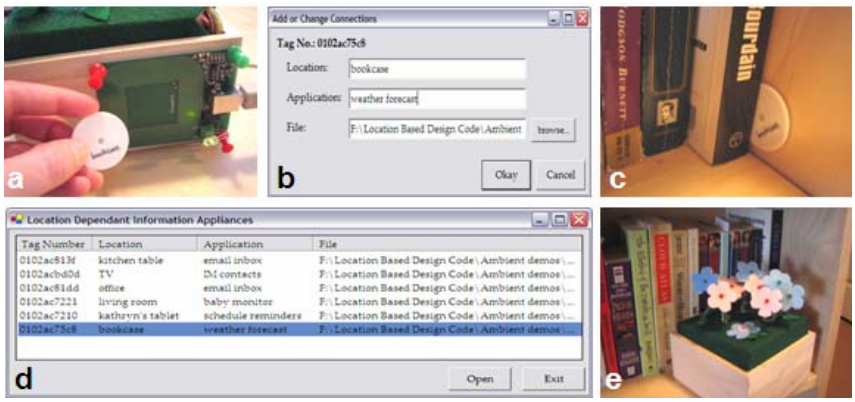

Fig.8: Assigning a tag to an application, and then placing it in a location

through a simple gesture. This works with Crabtree et al's understanding of place being interwoven with action and activities [5] since the space is now not only used as an contextual place for information display, but also allows for people to interact with the information *in place*. This permits the information *and* the interaction to be a part of everyday domestic routines.

4.3 Discussion

Going back to Bob's scenario, we can see how the Ambient Garden becomes more valuable in the domestic setting when it is *location-dependant.* Bob has three locations tagged. He now puts the Ambient Garden on his dresser in the morning displaying a weather forecast, making it much easier to decide what to wear. If he needs more details, he simply touches it and a detailed audio version of the forecast plays. He then takes it to the kitchen during breakfast where it shows the traffic conditions on his commute. Finally he places it on the family room mantle in the evening next to a photo of Ellen; this lets him see when she comes online so they can chat during the rare periods when their wake times overlap. Bob's roommate Catie now also uses the Ambient Garden, and has tagged two locations. Catie works from home. She moves the Garden next to her desk while Bob is at work, where it displays scheduling reminders from her calendar, so she doesn't miss scheduled phone meetings or deadlines. She also takes the Garden into the kitchen when she goes to make lunch or a snack and places it on the table (rather than the counter, Bob's breakfast place) where it shows the contents of her email inbox. Since the Garden now fits into Bob and Catie's natural routines and pathways through the home, it is much more useful and valuable to them. While the device is continually repurposed, it is easy to tell what information is currently displayed because it is being shown in the context of the household's daily routines by being placed in a location that helps that information make sense.

Design Guidelines. Our *location-dependant information appliances* also reflect 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 new applications still require programming knowledge to create, 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 [1]. Our current devices are run off a tablet PC, meaning that the tablet needs to be moved with the device, but again, it is

easy to imagine that if these were commercially produced, the computational elements could be built in.

Reflection. Of course, our two ambient displays are just examples; 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 [16, 4]. 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 [22, 1] and could again be repurposed as information displays by location. A lamp could be used for reading light when placed on a desk, and as a gentle information display when placed on a shelf.

Other more generic displays could also change the information displayed depending on where they are placed. A tablet placed by the entrance could run StickySpots. When moved to the kitchen, it could display a family calendaring program. You could also combine the physical devices with more conventional displays to create applications that work in tandem. For instance, the Ambient Garden could be used to "extend" a location from StickySpots. The Garden 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, you provide value beyond what is conventionally available. Imagine deciding to work at the kitchen table 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 also extended. As with StickySpots, our next step is to install these devices in real homes and evaluate them.

5 Discussion and Conclusions

The idea of using contextual locations to extend existing technology can be applied in many different ways. Like the Flexible Ambient Display project, other existing research projects could be extended or repurposed to take advantage of our findings. The Everywhere Displays movable projector [18] could be combined with instant messaging or email to create a location-based messaging or reminder system similar in goals to StickySpots. HomeNote [19] could be extended to multiple connected displays to combine their person to place messaging with place to place messaging within the home.

Current technology already in the home and that being designed for it could also be extended or improved by reexamining it in light of the study results. Rather than using a fridge display [17] to browse the Internet or check email (tasks unlikely to be done standing up or based in the kitchen), it could be used as a location-based messaging portal; or as a display for various information visualizations, that change over the course of the day in response to its location and the household's kitchen routines – weather, traffic or scheduling information during breakfast, news during lunch, and the evening's prime time TV listings at dinner. Imagine countertops or tables that were also information displays, so all your handouts, newsletters and schedules could

be downloaded from the web and spread out so you knew what was upcoming, and yet they could be also be searched, sorted and linked, so you would never lose, for instance, the form that went with that brochure. You could clear the table with one click to play a virtual game, and then have all your information right back where you wanted it afterwards. And your table could still be used for eating!

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 Conclude. We have presented case studies of domestic technology design along with design guidelines as a means to illustrate how findings from ethnographic studies about location use in everyday routines can be applied to the design of home technologies. While our 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. Ethnographic study findings often provide very detailed and valuable information, yet these findings are not always the easiest to apply to design. Thus, our main contribution is to show through simple and initial examples how one can design for home information and Contextual Locations [9]. StickySpots, our 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 the Glow Lamp and the Ambient Garden use the study results to extend an existing system to be of more value in the home. While both prototypes and the guidelines still need evaluation, we feel that they are good first examples of how to apply location-based design in the home.

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