The CareNet Display: Lessons Learned from an In Home Evaluation of an Ambient Display

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Abstract. This paper addresses users' experiences with an ambient display for the home. We present the design and *in situ* evaluation of the CareNet Display, an ambient display that helps the local members of an elder's care network provide her day-to-day care. We describe the CareNet Display's design and discuss results of a series of in home deployments with users. We report how the CareNet Display was used and its impact on elders and their care network members. Based on our findings, we offer lessons about how ambient display technologies could be improved to further benefit this growing user community.

1 Introduction

Though the potential benefits of ambient displays have been discussed [4,7,8,10,11,14], little has been shared about users' experiences with deployments of actual ambient displays in the home environment. Previously, we introduced the area of Computer-Supported Coordinated Care (CSCC) [3] which described the many people involved in the care of an elder and how technology might help them. This paper, however, focuses on the details of our first CSCC prototype, the CareNet Display. The CareNet Display is an interactive digital picture frame that augments a photograph of an elder with information about her daily life and provides mechanisms to help the local members of her care network coordinate care-related activities. We describe the CareNet Display's design and its deployments in the homes of several members of four different care networks for three weeks at a time; in these deployments, the data shown on the CareNet Display was collected from daily interviews with the elders and their caregivers. From our findings of these deployments, we suggest how CSCC tools can help elders and the members of their care networks. We also discuss the lessons we learned about the use of an ambient display in the home that we believe can be of benefit to other designers.

Because caring for an elder is often a secondary, yet important focus for most care network members, the nature of ambient displays appears to offer a good solution. This idea was previously explored by the Digital Family Portrait project [14] from the perspective of offering *peace of mind* to *distant* family members who are concerned for an elder. In our research, we are targeting the *local* members of an elder's care network who are responsible for providing the elder's *day-to-day care*. This change

N. Davies et al. (Eds.): UbiComp 2004, LNCS 3205, pp. 1-17, 2004.

in focus resulted in our design sharing much more detailed and potentially sensitive information about the elder, and in some cases, other network members.

In this paper, we discuss the design and *in situ* evaluation of the CareNet Display. We share many findings, including details of how it was used in the home. We then offer considerations for the design of ambient displays for the home and suggest ways in which ambient displays could be used to further benefit this growing community.

2 Design of the CareNet Display

For readers who are not familiar with Computer-Supported Coordinated Care [3], we offer a brief background. Specifically, we discuss the local members of the care network who provide an elder's day-to-day care; these members are the target users for the CareNet Display prototype. We then describe the CareNet Display's design.

2.1 Background on Care Networks for Elders

Our previous eldercare research [3] explored the many people who provide an elder with the care she needs to remain at home. These people – often family, friends, and neighbors of the elder – comprise her *care network.* Paid help, such as professional caregivers, doctors, nurses, pharmacists, and house cleaners, may also be involved. Care network members – particularly the family, friends, and neighbors – face many challenges. For several of these members, caring for the elder is an important but secondary focus, as they have their own families, careers, and problems to manage.

Care network members generally fall into one of three categories, based on how providing care impacts their lives: drastic life changer, significant contributor, or peripherally involved member. The *drastic life changer* has made major changes to her own life to care for the elder. This often involves sacrificing a career, hobbies, and sometimes family. There is usually one drastic life changer per care network, often the elder's spouse, child, or a professional caregiver. Caring for the elder is typically a primary focus for the drastic life changer. The *significant contributor* provides regular care for the elder; this care has a noticeable impact on the significant contributor's life, but she is still able to maintain her own life as a primary focus. There are usually at least a few significant contributors in a network, often the elder's nearby children and close friends. *Peripherally involved* members provide care that is meaningful for the elder, but is usually sporadic social and home maintenance types of care. For the peripherally involved member, providing care generally has minimal impact on her own life. These members are often children who live at a distance, grandchildren, friends, and neighbors.

Technology can help the various members of an elder's care network. Because caring for an elder is often a secondary focus for so many members, ambient display technologies may offer a solution. The idea of using ambient displays was reinforced by the positive feedback from the Digital Family Portrait project.

2.2 The CareNet Display: Target Users and Design

The CareNet Display's target users are the *local* members of an elder's care network who provide her day-to-day care; the elder does not use the display. Most users are aged 40-65, however some could be teenagers and others in the elder's age group. Comfort and experience with technology vary greatly among users. More than one member of a care network would have a CareNet Display — probably at least the *drastic life changers* and *significant contributors*. Most users will use it at home.

The CareNet Display has two basic modes of use: ambient and interactive. The main screen operates like an ambient display, where the user can get a general idea of the elder's condition in passing. Each of the seven main icon types – meals, medications, outings, activities, mood, falls, and calendar – change to convey high-level status (*e.g.*, everything is okay, something unexpected happened, the system is not working). In many cases, the display shows multiple icons of the same type (*e.g.,* three meal icons are used to represent breakfast, lunch, and dinner). The display's interactive quality allows the user to "dig deeper" by touching icons. When the user touches an icon, the photo of the elder is replaced with details for that event (*e.g.,* the morning medications view shares *when* the elder took morning medications, *what* she took, and *if* anything unexpected happened; it also allows network members to add a note to the event). Five-day trend views for the event types are available (**Figure 1**). The user also has access to events from previous days. We chose to include *seven* types of information largely due to considerations of usefulness and memory capacity. Much fewer than seven and the users would not get enough information; more than seven might result in information overload for some users. This, in addition to "Miller's Magic Number of Seven Plus or Minus Two" [12], resulted in our choosing seven types of information for the first version of the CareNet Display prototype.

The data provided in the CareNet Display would be collected by sensors and people, where "people" is the elder and/or certain network members. For instance, to help coordinate care-related activities, a user-editable calendar is provided that includes the elder's appointments and transportation needs (*e.g.,* users may sign up to provide transportation or add/edit an appointment), while sensors may be used to detect which medications the elder took [6]. Because this was an early deployment and one of the goals was to inform sensor design, we used people, not sensors, to collect the information. However, we spoke with other researchers at our lab who were developing the types of sensors we imagined using to ensure that the type and level of detail we collected were reasonable for sensors in the near future.

The types of information shared through the display were chosen based on roundtable discussions we conducted with 17 care network members in summer 2003 [16]. During the discussions, participants rated 20 types of information that they wanted to know about the elder (see Table 1). These 20 types were identified through interviews conducted at the beginning of our research [15]. Because we would have to collect the information about elders through frequent daily phone calls (further discussed in section 3.2), we chose the top seven types of information we could reliably get from elders and their caregivers. For example, though *disease-specific measurements* ranked #3, many elders do not take these measurements frequently enough for us to have collected accurate data for the deployments.

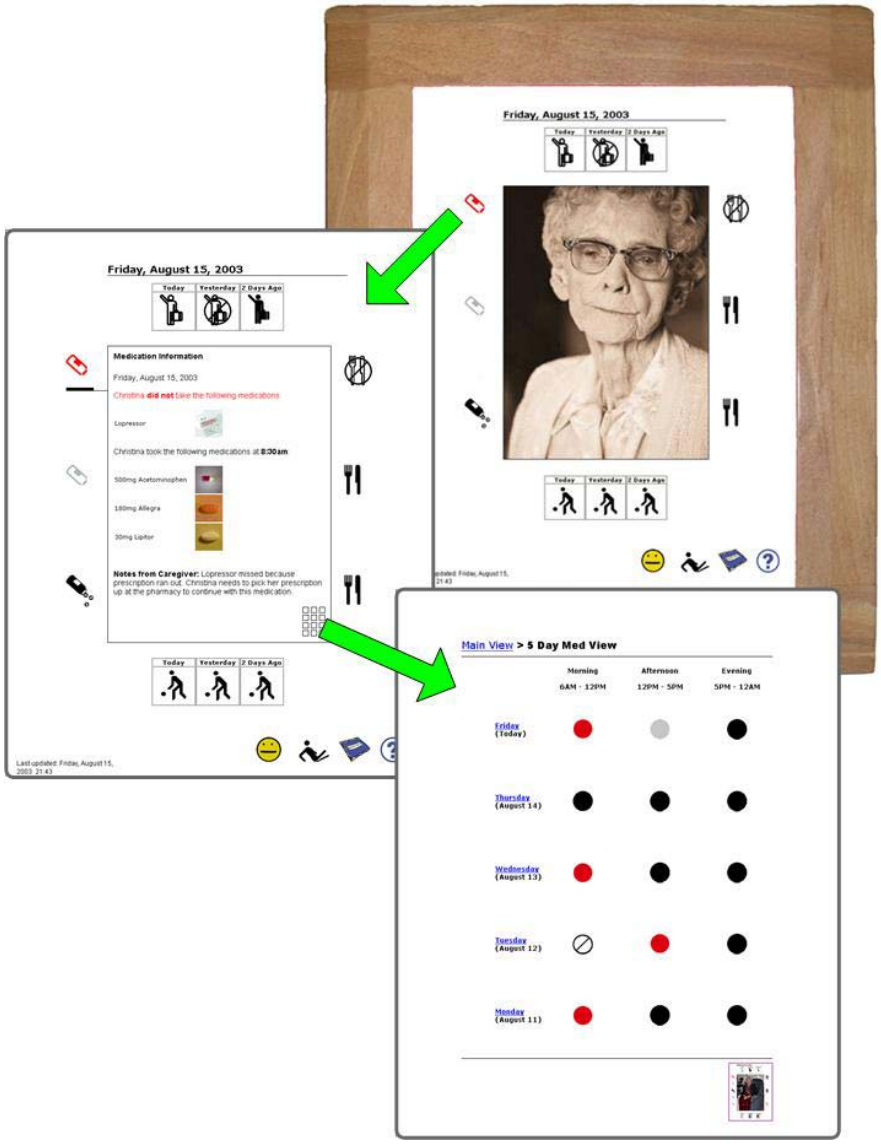

Figure 1. The CareNet Display prototype. The CareNet Display's main screen is on the top right. Users can get an overall picture of the elder's condition while passing by, or interact with the display by touching the icons which represent seven types of events—medications, outings, meals, activities, mood, falls, and calendar. On the left is the "morning medication" detail screen. Users can go from an event detail (such as morning medications) to a 5-day trend view (such as the medications trend shown on the bottom). From the trend view, users can return to individual events or the main screen overviews from previous days

Table 1. Ranking of the types of information care network members want to know about elders, based on results of a card sorting exercise. The information types in bold and followed by a "•" were those used by the CareNet Display. *Distance walked* and *Dressing* tied for #17

1.	**falls •**	11.	visits
2.	**meals •**	12.	weight
3.	disease-specific measurements	13.	water intake
4.	**medications •**	14.	messaging
5.	vitals	15.	bathing
6.	**mood •**	16.	car trips
7.	**calendar •**	17.	distance walked
8.	household needs	17.	dressing
9.	**activities •**	18.	phone calls
10.	**outings •**	19.	toilet use

Because the CareNet Display shares potentially sensitive information about the elder, it is designed to give the elder some control over her information. When the display is set up, the elder chooses which user can see which types of information, for example, it is possible that not all display users would see medications. Once permission has been granted to a user, the elder still has the opportunity to "not share" an event's update. However, if the elder's cognitive abilities are compromised, this control could be given to someone else, for example, her power of attorney.

Once we felt we had a good understanding of the needs of this population and the type of design that might work for them, we conducted a series of *in situ* deployments. This was particularly important, considering the sensitive nature of the types of information we planned to share through the CareNet Display. We also had to investigate how sharing this information among network members would impact the elder's care and the lives of the network members. We built three prototypes of the CareNet Display to deploy in the homes of target users for three weeks at a time to see what impact it would have on elders and the members of their care networks.

3 Details of the *In Situ* Deployments

To test the hypothesis that ambient displays can positively impact the local members of an elder's care network, we conducted a series of three-week long *in situ* deployments of the CareNet Display prototype. The deployments were conducted from September to December 2003 by members of the research team. In this section, we discuss the profiles of the participants and details of the deployments.

3.1 Participant Profiles

Members of four different care networks of elders who live at home and require regular care participated in our CareNet Display deployments. For each care network, the elder and at least two members not living with her (or each other) participated. Participants were recruited by the research team who used a variety of methods:

giving talks at geriatric care networking conferences, placing posters in senior centers, and working with local eldercare experts. Participants were (see Table 2):

- 4 elders, three female, who live at home and receive regular care. All live in the greater Seattle area; the females live alone. Ages ranged from 80-91; and
- 9 members, five female, of 4 different care networks. Participants live in the greater Seattle area and not with the elder or each other. Ages ranged from 51-65.

In most cases, other members of the participants' households – *i.e.,* children and partners/spouses of the participants – who were peripherally involved members of the elders' care networks also provided feedback about the CareNet Display.

Table 2. Participants in the *in situ* CareNet Display deployments. Pseudonyms are used to protect the participants' identities

Elder	Network Member	Relationship to Elder	Role in Care Network
Grace	Vera	Daughter	Drastic Life Changer
	Donna	Daughter	Significant Contributor
Rita	Hannah	Daughter	Drastic Life Changer
	Simon	Son	Significant Contributor
	Zack	Son	Significant Contributor
Minnie	Myra	Daughter	Significant Contributor
	Esther	Daughter	Significant Contributor
Ted	Saul	Son	Significant Contributor
	Cliff	Son	Significant Contributor

3.2 Deployment Details

The three-week long deployments were conducted one network at a time. In each deployment, two or three network members had a CareNet Display in their homes. Members were able to use the display however they liked; they received no special instructions from the evaluators on how or when to use it.

The prototype used a touch-screen tablet PC housed in a custom-built beech wood picture frame (shown in **Figure 2**). The contents of the display were shown through a web browser, though that was not obvious to participants as the "full-screen" mode removed any distinguishing browser characteristics. A wireless GPRS card provided always-on internet access so that the CareNet Display could be updated throughout the day without disturbing the participants' phone lines or requiring them to have broadband internet access.

Figure 2. The CareNet Display prototype used in the deployments. The prototype uses a touch-screen tablet PC housed in a custom-built beech wood frame

To collect the data that was shown on the displays, evaluators spoke to the elders and/or their caregivers[1] three to six times per day by phone, including weekends and holidays. At the end of every phone call, the elder was asked if it was okay to share the information with display users. Updates were immediately made by the evaluators using a web-based tool (**Figure 3**). Participants did not receive any notification when updates were made. The substantial level of effort required on the part of the evaluators, elders, and especially the already overburdened caregivers was the main reason for our using a duration of three-weeks; it seemed to be at the limit of the time commitment many of the drastic life changers were willing to make.

All participants, including the elders, were interviewed before and after the three-week deployments. Most interviews lasted 60-90 minutes. Researcher notes, participant-completed questionnaires, audio recordings, and photographs were used to document the deployments. Incentives varied based on level of participation in the deployment. Network members who had the CareNet Display in their homes received $150 US. Incentives for the elder and other data providers varied between $75-300 US based on how often they provided updates.

[1] When the elder could provide reliable updates, evaluators spoke directly with her; otherwise the evaluators spoke with the caregiver(s). For Rita's deployment, two of the three caregivers who helped provide data about her were also display users—in this case, different caregivers were responsible for different types of data.

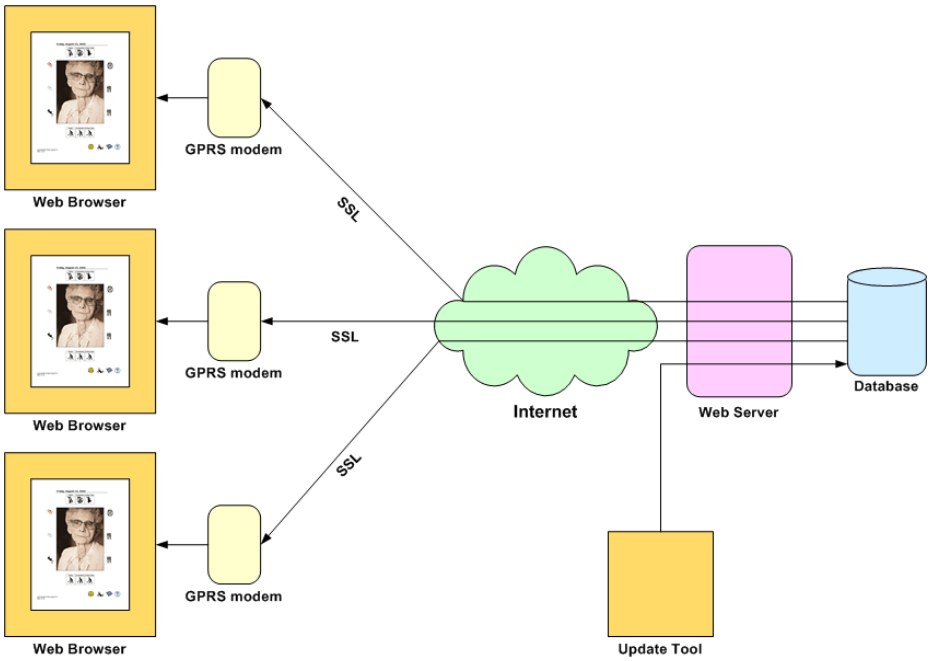

Figure 3. CareNet Display Prototype Architecture. Updates were made by evaluators through a web-based tool. Data was pushed to the displays through an always-on connection from a GPRS modem

The deployment began for care network members with a semi-structured interview and an exercise about the types of information they would like to know about the elder. The CareNet Display was then set up in the participant's home, photographs were taken of his chosen placement, and he was provided with a printed help booklet. Participants were mailed a questionnaire to be filled out half way into the deployment. In most cases, in addition to "official" participants, other network members residing in the same household as the CareNet Display also filled out the questionnaire. The deployment ended with another questionnaire and semi-structured interview. Photos were retaken if the participant had moved the display.

Elders began by answering questions about their schedule (*e.g.,* medication schedule, upcoming appointments), typical activities, fall history, etc. – the information we needed to create their displays. We discussed what information the elder was comfortable sharing with the network members/display users who were participating in the deployments (*i.e.,* the elder chose *who* could receive *which types* of information). We took photos of the elder and her medications. A semi-structured interview was conducted at the end of the three-week deployment.

4 Analysis

In this section, we discuss several findings from the CareNet Display deployments. We share the participants' general feedback on the CareNet Display, where they used it in their homes, and how they interacted with it. We also discuss the CareNet Display's impact on the lives of the care network members and the elders' care.

4.1 General Feedback, Popular Locations, and Typical Interaction Modes

The results of our deployments suggest that ambient displays can be an effective tool in helping local care network members with the tasks of information sharing and care coordination. The CareNet Display was well received both by the care network members and the elders. In all cases, the care network members who participated said that they would use such a display if it were given to them, and in most cases, they would purchase one if it were commercially available and affordable.

Participants thought that the display was aesthetically pleasing and blended in nicely with their décor, though some complained that it was a "little large." They tended to place the display in often used, common areas of their homes. For example, no participant kept the CareNet Display in a bedroom or bathroom. Instead, the displays were placed in the family/TV room, dining area, home office, or kitchen (**Figure 4**). When asked about what the elders thought of these placements, most found them to be acceptable. There was one case where a drastic life changer was uncomfortable with the display being kept in a "publicly accessible" location in her son's home, as she did not trust one of his frequent visitors; this concern was not shared by the elder or that son.

Reports from participants on how they interacted with the CareNet Display varied. As previously mentioned, the CareNet Display was designed to work as an ambient display and an interactive touch-screen device. Because the display's main screen behaves as an ambient display, it was not uncommon for participants to glance at it while passing by, merely to see if any icons were red; red icons signified that an event did not occur as planned, such as a missed, incorrect, or overdosed medication. Other participants often used the display as an interactive device, stopping and digging for details of the events, even when the icons were not red. In general, interaction patterns

Figure 4. The CareNet Display *in situ*. Participants kept the display in places such as (from the left) the kitchen, home office, TV room, and dining area

were dependent on the members' level of participation in the care network. Drastic life changers reported checking the display frequently through casual glancing, supplemented by occasional digging for details; significant contributors and peripherally involved members reported that they tended to interact with the display with higher frequency than drastic life changers – some reported as often as 10 times per day. This difference in behavior may have occurred because drastic life changers were usually already aware of many details about the elder due to their existing care responsibilities. For the significant contributors and those who are peripherally involved, the display offered an opportunity to increase their level of awareness about the elder; the information often gave them something to talk about with the elder (*e.g.,* "How was your ceramics class today, Dad?" "Did you see anything good on TV this afternoon?"). Most participants commented on how nice it was that they could get some information from a casual glance and that they felt comfort in knowing it was always there, but they could chose to ignore it.

4.2 CareNet Display Impact on Care Network Members and the Elder's Care

Participants reported that the CareNet Display had an overall positive effect on their stress levels during the deployment. A majority indicated a reduction in the amount of stress they felt in caring for the elder as a result of having the display in their homes and the homes of other network members; none of the participants reported an increase. As a result of the decreased stress levels, participants such as Myra and Cliff felt that their interactions with their respective elders were "more relaxed."

Getting information through the display, and not directly from the elders, also made network members feel as if they could treat the elder with more respect. For example, Myra enjoyed finding out about Minnie's activities and outings without having to be intrusive. These details are normally not part of their conversations, as Myra "kind of hate[s] to ask her [about them] time and time again." Similarly, Vera feels awkward discussing certain details with Grace, saying she feels she is "treating [Grace] like a child." With the CareNet Display collecting information for her, Vera had the information she needed to provide proper care and was able to have more "meaningful" conversations with Grace.

For all four care networks, the CareNet Display raised network member awareness about the elder's daily life, particularly for the significant contributors and peripherally involved members who lived with those members. In many cases, it also raised awareness of the extent to which other network members contributed to the elder's care. Much of this came from the detailed information the display provided, such as *what* Mom ate for lunch and *when,* or the calendar that showed the elder's various appointments and *who* was providing transportation. This detailed information and the ability to review information from previous days was used to improve the quality of care for some elders. In Rita's case, her son, Simon, and his wife noticed that Rita was eating the same thing, day after day. For a diabetic like Rita with mild dementia, this was not a good sign. Her network was trying to let her remain as independent as possible, but this additional information alerted them to the fact that she needed more care. Until Simon and his wife noticed this, Rita had been doing her own grocery shopping. Now, her care network members help with grocery shopping and make an effort to check the variety in Rita's kitchen when they visit.

These findings suggest that CSCC tools like the CareNet Display can make a meaningful, positive impact on both the care of the elder and the lives of her care network members. In light of these observations and the varied roles of potential users, it seems important for a device of this kind to include both ambient and interactive modalities. We would not be surprised to see the frequency of interactions with the device decrease in a longer term deployment, as it is possible that the high frequencies reported came from the novelty of having a new device. However, the ability to "dig for details" was consistently important to all participants.

5 Considerations for the Design of Ambient Displays

Despite the overall positive feedback the CareNet Display received, we found areas for improvement and challenges for future development. In this section, we discuss several lessons learned, in hopes that ambient display designers can apply our findings to their own designs.

5.1 When an Ambient Display Stops Being Ambient

In addition to the findings mentioned above, there was an additional factor to support the idea of ambient displays being good for local care network members: participants got upset when the CareNet Display stopped being ambient. This is the type of problem that *in situ* deployments are good at uncovering. Like computer screens and the Ceiva picture frame [1], the CareNet Display "glows" in the dark (**Figure 5**). This

Figure 5. The CareNet Display prototype in a dark room. The screen's "glow" can make the display lose its ambient quality

was a problem for participants who put the display either in their TV room or within view of their bedroom. We heard accounts of participants who were disturbed by the display's glow at night from their beds or while trying to watch TV.

This type of display behavior might be a useful way to grab the user's attention if something significant happened, but under normal circumstances, it should be avoided. A solution could come from incorporating a photosensor and/or motion detector in the display to detect when the display could be dimmed.

5.2 Providing Sufficient Information Without Complicating the Display

The CareNet Display's main screen contained icons to represent seven types of information for a number of events, for example, three meal icons were used to represent breakfast, lunch, and dinner. Each icon conveyed the event's state at the time the display was last updated, in an effort to provide the user with complete information and not portray a false sense that "everything is okay" if it may not be. For example, there were icon representations for the following states:

- Event occurred as planned,
- Something unexpected occurred,
- Event has not yet occurred (*e.g.,* it isn't yet time for lunch),
- Event did not occur (*e.g.,* lunchtime has passed, and the elder did not eat),
- The elder has chosen to not share the event, and
- The system cannot report the event

Red icons were used for the "something unexpected" state. Few participants understood the subtle visual differences in icon representation; in all but the "elder has chosen to not share," the states were distinguished only by icon color. Most participants just looked to see if any icons were red. Though the many icon representations did not seem to confuse participants, they may have gotten a false sense that "everything is okay," as most did not notice the difference between, for example, "system is not able to update event" (gray icon) and "event occurred as planned" (black icon). After our end of deployment interviews, it seemed as if "event has not yet occurred" was not an important distinction to make (*i.e.,* care network members know whether or not the time for lunch has passed). However, they seemed to find the other states to be important. Further research should be conducted to investigate how to effectively communicate these distinctions without overly complicating the display or compromising its ambient quality.

5.3 Providing the "Human Touch" from Sensor Data

In the end-of-deployment interviews with both care network members and elders, we talked about the vision of sensors collecting most of the data that the evaluators collected during the deployments. Though there were mixed reactions about sensors in the elder's home, there was a consistent reaction from the significant contributors and peripherally involved members about the type of data that would be provided. Most expressed the importance of the data having a "human touch." They were afraid that sensors would provide impersonal data. In many cases, they wanted to know qualitative details about the events, for example, not just *that* the elder knitted, but

what she knitted and *for whom*, or *why* the elder was feeling bad, not merely *that* she was feeling bad. A popular suggestion was to incorporate a daily narrative provided by the drastic life changer about how the elder is doing and what her day was like.

When we discussed the idea of adding the "human touch" with the drastic life changers (even before posing the narrative idea), most expressed concern; they immediately suspected that the responsibility would fall to them. An alternative that may be able to satisfy the display users without overburdening drastic life changers could be to use an interactive system that prompts the elder to provide a verbal narrative that could be added to the display. An interesting challenge for future work in this area is how to convey this human quality while using data largely provided by sensors and not adding to the responsibilities of already overburdened members.

5.4 Privacy Considerations

The CareNet Display provides two ways for the elder to control her information: she decides who can see what type of information, and she can choose to not share the update for any event, even after permission for that type of event has been granted. Though no elder in the study took advantage of either of these controls, it was important to both elders and their care network members that the controls were available. For the elders, it gave them an enhanced sense of control and increased their trust in the technology. For care network members, most thought that the controls were important so that the elder could maintain as much of her independence as possible, while a few thought it was important to signify when something was a problem. In one participant's words, "if Mom didn't want to share what she was eating, there'd probably be a reason." Future designs could explore other levels of disclosure, such as only alerting certain network members when something unexpected occurs (*e.g.*, a member who does not normally see medication information, might receive it only if the elder misses or overdoses on a medication).

We also discussed the idea of the CareNet Display being used by more members of the elder's care network (in our deployments, only two or three households per network had displays). Prior to the deployment and in our earlier research, elders claimed to be very comfortable about sharing their information with the local members of their care networks. The only exceptions mentioned were the members who lived at a distance, as the elders saw no reason to share details about events like medications and meals with members who could not immediately come to their assistance if something bad happened. After the experience of the deployments, some elders changed their minds. Though they were still very comfortable sharing their information with the network members who participated in the deployments, they noted special cases – *e.g.,* the alcoholic grandson or the forgetful neighbor – with whom they would not be comfortable regularly sharing information, or at least not all types of information, even though these members are still important to the elder.

Through the CareNet Display deployments, we have shown that ambient displays have the potential to be a powerful tool for local members of elders' care networks. We have also discussed some of the problems with our design, suggested ways to improve these problems, and offered challenges for future work in the area.

6 Related Research

In this section, we discuss research in the areas of ambient displays for care network members and ambient displays that have been evaluated in their intended settings.

As mentioned previously, the CareNet Display builds on research done by Mynatt *et al* on the Digital Family Portrait [5,14], but targets a different audience and uses modified data collection and analysis techniques. The Digital Family Portrait uses an ambient display to provide distant family members of an elder with enough information to give them the peace of mind to allow the elder to age in place, while respecting the elder's privacy. The ambient display's form factor is that of a digital picture frame. However, instead of a static photo of the elder, the border surrounding the static photo of the elder is augmented with daily updates of certain aspects of the elder's life – the sort of information that a neighbor or other member of the elder's household could easily observe. In the first version of the Digital Family Portrait, a photo of the elder was surrounded with 11 days worth of information on one screen, represented by various icon visualizations. The types of information shown were overall measurements of health, relationships, activity, and events (where measurement was based on a scale of 10). A prototype of this first version was evaluated in a field trial (described below). Based on field trial results, the design was revised to be less complicated, the "events" category was dropped, measurements were reduced to a scale of four, the main screen showed 28 days of information, and layers were added for less common needs. They also added representations to the main screen for alarms and system-detected trends. The new visualizations went through usability studies for clarity, but no field trial.

Like the Digital Family Portrait, the CareNet Display uses an augmented digital picture frame to provide information about an elder to members of her care network. However, in the case of the CareNet Display, the target users are the local network members responsible for providing the elder with the day-to-day care she needs to be able to age in place. Even though both projects target members of an elder's care network, the needs of the users are different. Because of this change, the CareNet Display shares information that is potentially much more sensitive and in more detail than what the Digital Family Portrait shares—the types of information the members need to provide the elder with day-to-day care. For example, the CareNet Display not only shows that medications were taken as planned, but includes *which* medications and *when* they were taken. Similarly, the CareNet Display does not show a general measurement of activity per day, but rather *which* activities were performed and *when*. It also provides mechanisms to help the users coordinate care-related activities. Because of the sensitivity of the information on the CareNet Display, it is designed to give the elder some control over what is shared. In addition to sharing information about the elder, it also shares information about other network members (*e.g.,* Mary is taking the elder to the doctor's office on Tuesday; Sam visited the elder last Thursday). Because of the CareNet Display's intended use, updates need to be made throughout the day as events occur, and the level of detail and reliability of the shared information is critical to the CareNet Display's success.

Regarding the evaluation of the Digital Family Portrait, a 9-day *in situ* field trial was conducted of a prototype of the first version of the design with one family—a grandmother and two of her grandchildren. To collect data to update the displays, the

evaluators conducted phone interviews once per day with each participant and subsequently updated the displays remotely. Participants were provided with a laptop, modem, and internet account so they could view the Digital Family Portrait as a web page on the laptop. At the end of the daily data collection phone call, each participant was asked to view the portrait, then answer a daily questionnaire to provide qualitative feedback. In this paper, we present a more in-depth study with several care networks validating the general idea of the ambient picture frame form factor and offer specific design lessons for such displays. Together, the Digital Family Portrait and CareNet Display projects address the needs of most of the members of an elder's care network.

Other research has evaluated ambient displays in the office/academic environment. Mankoff *et al* [11] designed and deployed two ambient display prototypes, the BusMobile and the Daylight Display, in the windowless undergraduate computing laboratories at the University of California, Berkeley. The BusMobile alerts lab users of how close several commonly used buses are to the nearest bus stop. The Daylight Display provides information about the level of light that is currently outside. The results of their *in situ* deployments were used to investigate and propose a new set of heuristics to tailor the discount usability method, *heuristic evaluation,* to ambient displays. Heuristic evaluation is traditionally used for evaluations of desktop software applications and web sites.

Ho-Ching *et al* [9] designed an ambient display for the deaf that visualizes peripheral sound in the office. They conducted an in-lab experiment and a one-week *in situ* evaluation of their Spectrograph display with one participant. Mynatt *et al* [13] deployed the Audio Aura system in their research lab and got feedback from co-workers who experienced the system. Audio Aura uses sound to keep office inhabitants in touch with events taking place at their desks. Cheverst *et al* [2] deployed Hermes, a system of interactive office door displays, in the computing department at Lancaster University. Their system essentially replaces post-it notes by allowing visitors to leave electronic notes for the office occupant when he is out.

Like Mankoff, Ho-Ching, Mynatt, and Cheverst, we evaluated our ambient display prototype with target users in the intended setting. However, our ambient display was targeted for the home environment, a very different set of users, and included an interactive modality[2].

7 Conclusions and Future Work

We have described the design and in home evaluation of an ambient display prototype, the CareNet Display. We discussed how the display affected the quality of care and lives of elders and their care network members. We also shared many of our lessons learned, including successes and areas for improvement. We hope that this research helps build a body of knowledge about the use of ambient displays in the home environment from which ambient display designers can learn.

Many challenges remain. An important next step is to explore what happens to the acceptance of technologies like the CareNet Display when sensors are introduced to

[2] The Hermes system also included an interactive modality

fill the role of human data collectors. Are elders comfortable living in a home filled with sensors? Do care network members trust the data reported by sensors? How is the network affected by sensor or system failure? A fully working system could also enable longitudinal deployments to uncover other unexplored issues. What happens when the technology gets beyond any novelty effects? How are the privacy controls used, and are they sufficient? What social issues do technologies like the CareNet Display introduce to the care network? Do such technologies contribute to a reduction in communications or visits with the elder overtime?

More work is also needed to investigate mechanisms that elders could reasonably use to control the distribution of their information. In our deployment, the elders controlled their information by talking with human data collectors who controlled the system. Additional design considerations, such as adding audio to the display when a significant or unexpected event is detected and offering form factors other than a picture frame (*e.g.*, handheld computer or computer desktop background), should also be investigated.

Conducting studies of ambient display technologies in their intended environments provides researchers with insight into how new tools are used and what effects they have on the members of the communities who use them. Our explorations indicate that ambient displays can be a key solution for a large and growing community of users who have a significant need for help.

Acknowledgements

We would like to thank the many people who contributed to this work, including: Morgan Ames, Anthony LaMarca, Jeff Towle, Lenny Lim, Jimmi Montgomery, Gaetano Borriello, James Landay, Ken Smith, Cherie Fenner, Michael Ham, Carol Johnston, Asuman Kiyak, Linda Reeder, Sandy Sabersky, Karen Sisson, Jay Lundell, Brad Needham, Margie Morris, Eric Dishman, Batya Friedman, Bill Schilit, Sara Bly, Ken Fishkin, and Miriam Walker.

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