VideoProbe: Sharing Pictures of Everyday Life

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ABSTRACT

VideoProbe is an example of a technology probe, which combines the goals of gathering data about daily family life, inspiring ideas for new communication technologies and testing them in real-world settings. Family members living in remote households can share pictures and personal information with each other via a closed, secure network. This paper reports our experiences installing videoProbes in two multi-household families as part of a longitudinal participatory design project. The project not only provided an intimate view of the families and the requirements for a real-world system, but also led us to a new concept of networked communication appliances.

Categories and Subject Descriptors

H.4.3 [**Information Systems Applications**]: Communications Applications; H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems; H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces

Keywords

Communication appliance, participatory design, inter-family communication, domestic technology, technology probe.

1. INTRODUCTION

The interLiving project is part of the European Disappearing Computer Initiative and focuses on developing technology to support communication among family members located in different households. We use a participatory design approach[6] and have worked closely with three Swedish and three French distributed families over a period of approximately three years. The project poses several methodological challenges. First, we need effective ways to learn about how existing families communicate, in order to identify areas for improvement. However, we cannot simply videotape family members at home, in all aspects of their family life. Instead, we must find creative ways of gathering information about them while ensuring their privacy[9]. Also, we must be wary of the illusion of our own expertise: all of us have families and all of us have communication strategies for dealing with them. But families are different and we need methods for obtaining an in-depth understanding of how other families communicate.

Second, an important element of our research agenda is to identify the design problem. As Crabtree et al. point out[1], the question is less how to build a particular system, but rather determining what to build. We need effective ways to interact with the families, including children and grandparents, so we can generate and explore potential design ideas. Although we contribute technical and design expertise, we also need their input, especially ideas that are derived from their particular family contexts, relationships and communication needs.

Third, we need methods for determining success in the real world. A system that works technically in the lab or receives a positive evaluation in a formal user study may not be accepted by family members in the context of their daily life. Unlike work settings, in which we can usually clearly define goals or metrics for success, in a home setting, we must rely on more qualitative forms of evaluation. While there may be some recognizable "tasks", such as coordinating appointments among family members, much of family life does not involve goals and views of success may differ. For example, parents may highly value a system that tracks their teenage son, but he may find it oppressive. So we need ways to evaluate systems outside the lab and see how and if they are accepted in the real world.

We developed a research method, called a *technology probe*[10], to help us address some of these methodological challenges. A technology probe is a single-function device that is installed in a research setting for a limited time and has three interwoven goals: to inspire users and researchers about new design possibilities (a design perspective), to collect data about users and their communication patterns (a social science perspective) and to field-test technologies in a real-world setting (an engineering perspective).

Technology probes are designed to be extremely simple, usually with a single function, while leaving the interpretation of how to use them as open as possible. The goal is to feed the design process: participants gain experience and new ideas from living with new technologies and researchers obtain data and design ideas from the participants and their use of these technologies in context.

Note that technology probes should not be viewed as early prototypes. They must be technically sound and robust enough to be used on a day-to-day basis without technical support. At the same

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Figure 1: VideoProbe installed in a student apartment and an established family's house.

time, they are designed to be thrown away and are not considered technical precursors to later systems. Technology probes should have a single function, with as simple and direct an interface as possible. While this poses an interesting design challenge, it does not require a complex task model or analysis of usability trade-offs across a variety of features. A probe's single function must be sufficiently attractive that users want to interact with it as is, without training or externally-imposed use requirements. A successful technology probe will inspire ideas and should have "interpretive flexibility"[14] encouraging users to generate unexpected uses. Finally, technology probes must be instrumented to provide data about their use. Subsequent analysis should be available to both researchers and the participants.

VideoProbe helps us address the three methodological challenges above by 1) providing a non-obtrusive way to learn about a specific family's communication while letting them control their privacy, 2) letting them use and explore novel communication technologies in their own homes, which provides a much deeper foundation for later collaborative prototyping activities, and 3) providing a preliminary measure of success, based on the families' patterns and level of use and their reactions over a period of time.

VideoProbe is one of two original technology probes: its function is to take snapshots of daily life of families at home and exchange them with family members living in other households. A previous paper[10] introduced the concept of technology probe, introduced messageProbe and videoProbe, and described the results of our first installations of messageProbe. This paper describes the technological design and use of videoProbe. We then report on our experiences installing videoProbes in two multi-household interLiving families in France. We describe how videoProbe helped us address the three design challenges identified above, and how it influenced our thinking about a novel kind of communication technology, which we call "communication appliances". We conclude with reflections on the use of videoProbe in particular and technology probes in general, as a design methodology.

2. VIDEOPROBE

VideoProbe is an autonomous device that facilitates simple and asynchronous communication by allowing users to share pictures of people, objects and everyday life. The hardware includes a screen and a movable video camera, connected to other videoProbes located in remote households of the same family (Figure 1). Each videoProbe automatically takes a snapshot whenever it detects that something has changed in front of the camera, after a delay of three seconds. These images are then shared with the other videoProbes in the same family network. Family members can browse through these snapshots, delete them, let them "fade away" and disappear or explicitly save them in a photo album.

Family members may decide to explicitly take a picture by placing an object or person in front of the camera and holding it steady for three seconds. The camera can also be moved and oriented to take a shot. However, videoProbe normally takes pictures automatically, capturing images when people stop moving. The result is a series of "day-in-the-life" photographs, which generate the feeling of being together at a distance, sharing the events of everyday life.

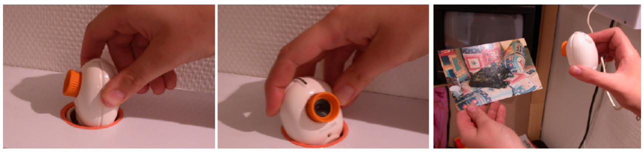

Figure 2: The video camera can be turned or used to actively take a photograph of a particular object.

Figure 3: VideoProbe and its remote controller.

A key characteristic of videoProbe is that it is extremely easy to use: taking a photograph is simply a question of moving one's body. This enables everyone, including grandparents and children, to actively participate. Since videoProbe uses a pre-established closed network that includes only specified family members, family members need do nothing more to send or share images.

2.1 Hardware Description

The fact that videoProbe was destined to be placed in the family's houses, in full view, posed important aesthetic considerations. First, videoProbe had to fit into highly diverse decorating schemes, from funky student apartments to established adult decors (Figure 1). Second, family members had already expressed their dissatisfaction with high-tech objects such as computers and their associated wires, so we needed to create an object that disappeared into the fabric of the house. Our solution was to embed the videoProbe flat screen into a white rectangular box (to hide the hardware) and to place a tiny video camera on top.

The egg-shaped video camera can be oriented in various directions or maintained in a stable position in the hole on top of the box (Figure 2). The camera can also be turned towards the wall as a quick way to ensure privacy. A 1.5m cable is hidden in the box which permits a user to extract the camera and use it to take pictures. The cable can be stored by feeding it back into the hole. Two speakers embedded into the white box provide auditory feedback about videoProbe's activity.

We chose an Apple Macintosh Cube for its aesthetics and silence, critical in a home setting. Although separate from the white box with the screen, it must stay relatively close, preferably hidden out of sight. The display is a 15-inch Wacom Cintiq LCD with a resolution of 1024x768. A wireless connection to a router and an ADSL modem allows videoProbe to be situated anywhere in the house while remaining constantly on-line. The webcam is a USB

Philips ToUCam Pro grabbing 640x480 images at 25 frames per second. We modified a Keyspan USB Digital Media Remote controller (Figure 3) to enable users to browse through the images. We covered most of the buttons, leaving only six: forward, backward, begin and end of the album, delete (to remove a photo) and save (to add a photo to the album).

2.2 Software description

The videoProbe software is written in C++ and uses the videoSpace toolkit[15], which grabs and displays video and provides basic video processing algorithms such as image differencing. VideoProbe has two modes: camera and browser. The user can switch between them with the remote controller. In camera mode (the default), videoProbe acts like a mirror until it detects a potential shot: the user can see his or her image on the screen. When videoProbe decides to take a picture, it provides visual and audio feedback, displays the picture, sends it to the other videoProbes and returns to the mirror display. In browser mode, the user can flip through the shots that have been taken by any videoProbe on the family network.

Camera mode: Initially, the camera mode is active and the display is white. When something moves in front of the camera, the display fades to a mirror image of the video feed (Figure 4, upper row). The image is reversed, as with a real mirror. If the person or object that has been detected stays still for three seconds, videoProbe displays visual feedback, takes a picture, displays it for three seconds and sends it to the other videoProbes. Unlike the mirror image, the picture is not reversed, allowing users to read written text. The image is also larger than the mirror image to help users understand it is a snapshot, not the live video feed. As soon as nothing moves in front of the camera, the real-time video mirror fades out and the display returns to the initial white screen.

VideoProbe only takes a picture if the user stays still for three seconds in front of the camera. The user can thus control when a picture will be taken, simply by continuing to move. This has the advantage of reducing the number of uninteresting pictures, such as when someone just walks by the camera.

The interface provides feedback about the remaining time before taking a shot. When videoProbe detects a lack of motion, a gray translucent rectangle appears in the centre of the screen and grows over the live mirror video (Figure 4, lower row). When the rectangle reaches the full size of the video frame, the picture is taken (Figure 4, lower right). If motion is detected while the rectangle is growing, the rectangle disappears, cancelling the timeout, and grows again when the image is still again. Short sounds signal videoProbe's activity: when a picture is taken, videoProbe plays the sound of a camera trigger. If the snapshot is similar to the previous one, it plays a "dong" instead to illustrate that the snapshot will neither be stored nor sent.

In order to detect if something new is in front of the camera, videoProbe grabs images continuously and compares them to a reference image. When the grabbed image is similar to the reference image, the display fades to white. Otherwise, videoProbe must distinguish whether (1) someone or something has appeared in front of the camera; (2) light conditions have changed (usually when clouds hide sunlight or when someone switches the light on or off); or (3) the camera has been moved. VideoProbe must respond differently under these conditions. Under condition (1) it should get ready to take a snapshot if the image becomes still (but different from the reference image). Under conditions (2) and (3) it should update its reference image. Our solution is to assume condition (1) and once a picture is taken, compare it to previous snapshots. If it is similar to the last snapshot, it is ignored, i.e. it is not sent to other videoProbes. If, in addition, the last snapshot is similar to the previous one, it becomes the new reference shot. This approach reduces the number of false positives, without eliminating them completely: when condition (2) or (3) occurs, videoProbe just sends one snapshot.

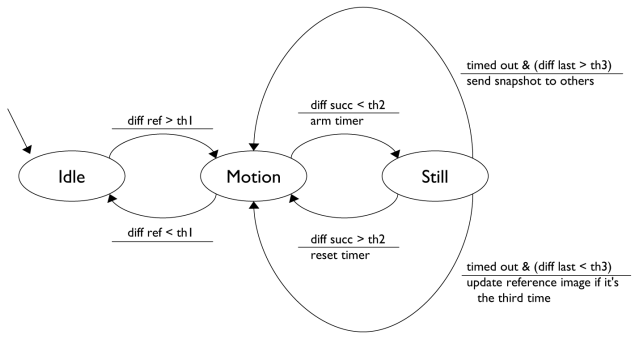

Figure 5: Simplified version of the scene change detection algorithm.

The camera mode of videoProbe is best described with the state machine that implements it (Figure 5). A transition between states occurs when the condition on the upper line of the label of the transition is true. "diff img > thx" states that the condition is true if the difference between the last grabbed image and the image img is greater than a threshold thrx. The image img can be ref, the reference image, succ, the last grabbed image, or last, the last snapshot that was sent to other videoProbes. When a transition occurs, the actions described in the lower line of the label are executed, e.g., taking a new reference image or arming a timer.

Browser mode allows users to view snapshots taken by both local and remote videoProbes. When a picture is taken, videoProbe automatically stores it locally and sends it immediately to all remote videoProbes in the family network. Each videoProbe stores local and remote images in a single chronological sequence. To enter browser mode, the user presses the backward button of the remote controller. VideoProbe then displays the most recent picture in the sequence. By pressing the backward, forward, begin and end buttons, she can browse through the image sequence. If the backward or forward button is kept pressed, the images flip quickly. We investigated other types of display, such as an overview of multiple pictures, but the complexity of interacting with such visualizations led us to choose a picture-by-picture view, as in an actual photo album.

We were concerned that videoProbe might take a large number of uninteresting pictures because of conditions (2) and (3) described above. This would have made interaction via the picture-by-picture view cumbersome: the user would either have to browse until she found an interesting picture or she would have to explicitly delete useless pictures. This could also have caused storage problems on the local hard drive. We decided to use an aging mechanism that modifies the appearance of the snapshots as they get older and deletes them automatically after five days if they have not been explicitly saved. This significantly simplifies storage and navigation and we hoped it would encourage people to use the videoProbe regularly, in order to keep a steady stream of images. To display the aging process, photos first lose their colour and fade to greyscale. The brightness is then increased, so they lose contrast and turn into all-white images (Figure 6).

Users can choose to store a picture in the album by pressing the save button on the remote control, and can remove a picture from

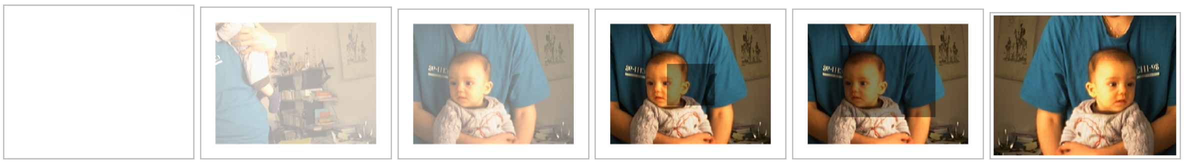

Figure 4: Screenshots of videoProbe's camera mode.

Figure 6: Picture aging: colours and contrast fade out progressively over several days.

the album with the same button. The images in the album are kept in the same sequence as the other images (again to simplify navigation), but they do not age nor disappear, and keep their original colours. In order to distinguish between these two types of images, especially for recent pictures that are not in the album and have not yet lost their colours, album pictures are displayed straight, while others are slightly rotated which gives an impression of disorder, like pictures spread out on a table.

Once a picture is taken, it is automatically sent to other videoProbes in its network. A user can erase an image locally with the delete button of the remote control, but not prevent it from being seen in other households. This design choice can have major implications for users, so we explained it to them in advance and later asked them whether or not this was an issue.

2.3 Network and data gathering

We subscribed each of the participating households to an ADSL provider to obtain a high-bandwidth, continuous Internet access. We were concerned about potential network failures, so we chose a client/server instead of a peer-to-peer model. The server runs on a computer at our lab, permanently connected to the Internet, and receives pictures from videoProbes installed at the various households. This also helps us monitor usage data. Whenever a videoProbe is not connected because of a network problem, it stores pictures locally. As soon as the connection is back, it sends unsent pictures to the server, which forwards them to other videoProbes in the family's network, as soon as they are available. This architecture reduces network-related problems: two videoProbes need not be connected at the same time in order to exchange images. VideoProbe actions (new picture, reference image change) and users' actions (browsing, adding/removing pictures in the album, deletion) are logged together with their parameters and time-stamp. The log files are regularly sent to the server.

3. INSTALLATION

Installing videoProbe in the families' households proved more difficult than anticipated. Even though videoProbe is not a product, it must run flawlessly: users will stop using an unreliable system. This is somewhat at odds with the requirement that a technology probe is "unfinished" and open to interpretation by end users, and it requires extra work to make the system robust. For example, we discovered that our ADSL provider shuts down the connection once a day and allocates a new IP number, requiring the router to be reinitialised. In order to make the system as robust as possible, we implemented various watchdogs that check if the videoProbe software is running and responsive and if the network connection is up. If one test fails, the software client is killed and launched again. Even with these protections, and despite the ability to access the software remotely, we had to visit the family homes several times to fix network-related problems.

Families: We chose two of the three French interLiving families to test the videoProbes. The first family consists of two nuclear families, each with two parents and two teenagers aged 12 and 15. The father of one household is the brother of the mother in the other household. They live in multi-story houses in two Paris suburbs, separated by a one-hour car ride. They phone and visit each other frequently. The second family consists of three households. A nuclear family composed of the parents, a 12 year-old daughter and a two-year old son, live in a small town north of Paris. The father has two nieces who both lived in apartments at the beginning of the project, until one of them moved to an apartment in Mullhouse, about 500 kilometers east of Paris. The two cousins are very close to each other and their 12-year old cousin.

Installation: We successfully installed four videoProbes in two households of these two families. All family members had previously seen and experimented with the videoProbes in our lab during a previous workshop. In the first family, both households chose to place the videoProbes in their living rooms, in view of the people watching television and, in one case, of an open-plan kitchen. The videoProbes were installed for a month, but one family went on vacation for one week in that timeframe. In the second family, we began by installing videoProbes in all three households, when the two cousins were in Paris. However, during the originally scheduled test period, the internet provider had trouble connecting one of the nieces in Paris and the other niece suddenly moved to Mullhouse. So we travelled to her new apartment and installed a videoProbe there, which we connected to the nuclear family in Paris, for a period of one month.

Data Collection: We provided each household with a booklet with a set of questions and room for comments about their experience with the system. We also collected the images created by each videoProbe and the associated activity logs. Finally, we interviewed the families in their homes, before, during and after the test period, to better interpret our data. We also conducted a participatory design workshop with all of the family members who had used the videoProbes in which we co-designed ideas for novel communication technologies.

4. RESEARCH RESULTS

We defined three key goals for videoProbe: to provide a deeper understanding of how these particular families communicate with each other, to generate innovative ideas with contributions from family members as well as ourselves, and to provide a real-world test of the technology. The next sections address these goals in turn.

4.1 Understanding the families

One of the methodological challenges we identified earlier was to provide measures of family activity. The data we collected, especially images, gave us an intimate view of the families use of videoProbes which sparked questions that we asked in subsequent interviews and workshops.

Activity logs identify the household, date, time, unique identifier, and the specific action (taking a snapshot, looking at a previous image). They also provide unique identifiers associated with snapshots, providing a link to the actual image. Activity logs are large and we used them to identify patterns and interesting periods of activity. For example, we were interested in periods in which both households were simultaneously using videoProbe.

Figure 7 shows a 90-second extract from a time period in which household 1 spent 11 minutes while household 2 spent 7 minutes browsing and saving images. Here, someone from household 1, who has been browsing pictures for several minutes, displays and decides to save a picture that was taken 13 minutes earlier in household 2. At the same time, someone from household 2 arrives and the videoProbe takes two new pictures of him. He moves into browser mode, and saves the second picture he sees, which was taken earlier that morning in the other household. When we see the corresponding new pictures taken, we see that at least one of the household members is on the phone (we can see the other person, but cannot determine if he is also on the phone). We showed these images to the family members, who said they had been collaboratively browsing pictures and discussing them over the phone. This is a good example of how use of videoProbe increased other types of communication between the households in the family.

Quantitative analysis of images: We selected subsets of individual images in and categorized them. For example, in one three-day period we found that only 50

Video sequences: Family members discovered they could browse through many images quickly, creating a "time-lapse" photography effect. Inspired by this, we identified interesting time periods, extracted the corresponding images and turned them into a 10-15 frame-per-second video clip. The results provided a fascinating compressed view of family life.

One such sequence was taken in a niece's kitchen before the videoProbe was connected to her sister. A 2-minute clip shows her drinking her morning coffee and reading, giving us a concise overview of her morning routine. Another sequence shows a nuclear family sitting down to dinner when the mother is in the hospital. We see the father's interaction with his children as he struggles to make dinner.

We held individual family workshops at our lab. Showing these clips encouraged them to tell us more, both about the particulars of that day and details of their use of videoProbe. For example, the family described the father's frustration making dinner while his wife was in the hospital. He called her for advice, but never really succeeded according to the children. This lead to an impromptu brainstorming session: One idea was to place the videoProbe in the kitchen and give him a way of viewing a video sequence of her preparing the dish at an earlier time. Another was to create a videolink to her in the hospital, so she could show him what to do.

The video sequences were also useful diagnostic tools. For example, we noticed a large number of images that were taken when everyone was away. The video sequence showed extreme lighting changes due the camera position, which faced the glass door to the garden. In this case, we not only adjusted the videoProbe's sensitivity, but also changed the orientation of the camera.

Interviews and written logs: We asked family members to answer questions in a log book placed next to the videoProbe. They were very honest, sometimes exclaiming about an event or use of videoProbe that they particularly liked, sometimes complaining about the lack of specific features. For example, the videoProbe took a great shot of them together with a visiting friend and they wanted to send him a copy. We also interviewed family members in their homes before, during and after the installation.

Our goal of bringing the families closer together was clearly met: Members from both families spontaneously reported stronger feelings of sharing their lives. In the beginning, the families explicitly took pictures, partly to test how long it took for the other household to receive it. After a short adaptation period, videoProbe became part of their daily lives. One family member described his routine upon coming home from work: he turns off the alarm, checks for messages on the answering machine, and browses through images on the videoProbe to see what happened during the day.

We were interested in the variety of uses that family members discovered. Some were implicit: for example, one of the fathers discovered that his mother had visited during the day, but that his wife had forgotten to tell him. Others were explicit: family members often intentionally created pictures with the videoProbe. For example, the mother in one family went to the hospital for foot surgery. The other family members created a special greeting by taking pictures of their own feet decorated with humorous messages, which she saw when she came home. In some cases, family members explicitly took advantage of the fact that videoProbe takes pictures automatically. One family held a New Year's Eve party within the camera's field of view. The motion was sufficient to cause videoProbe to repeatedly update its reference image, resulting in a large number of candid shots. The family was delighted to review the pictures the following day and told us "We didn't need to take pictures of the party; videoProbe did it by itself!".

Although the videoProbe was installed with full permission of all family members in relatively "public" places in each household, family members were still concerned with privacy. They appreciated the auditory cues, which reminded them when videoProbe was actively taking pictures, but this was not deemed sufficient. Most asked for the ability to delete an embarrassing or unpleasing image before it was sent to the other households. Some family members also wanted to be able to shut down videoProbe from time to time, to ensure that no pictures are taken. We noticed from the images that family members accomplished this themselves by turning the camera to the wall. However, they were also worried about forgetting to turn it back on and missing images. One mother suggested introducing a short delay, to give her time to delete if necessary, but this would change the nature of the exchange if, for example, they were on the phone to each other and explicitly creating and sharing images in real time.

4.2 Generating new ideas

VideoProbe served to spark ideas and discussion of desirable technologies, via design exercises in our family workshops. Family members were asked to tell us stories about how they wanted to communicate with each other and then to mock-up or video prototype those ideas. In the earliest workshops, the ideas were relatively predictable, such as Dick Tracy radio watches and improved telephones. Later workshops produced more intriguing ideas, such as a radiator that wafts pleasantly- scented air through the house when a family member from the other household arrives. After the families

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House1 4-Apr-03 Fri 19:50:25 -- next image
House1 4-Apr-03 Fri 19:50:26 -- put in album 2003-04-04-19-37-14-House2.jpg
House2 4-Apr-03 Fri 19:50:55 -- add image 2003-04-04-19-50-55-House2.jpg
House2 4-Apr-03 Fri 19:51:04 -- add image 2003-04-04-19-51-04-House2.jpg
House2 4-Apr-03 Fri 19:51:04 -- image browser enter mode
House2 4-Apr-03 Fri 19:51:07 -- previous image
House2 4-Apr-03 Fri 19:52:05 -- put in album 2003-04-04-07-53-13-House1.jpg
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Figure 7: Sample of data log, showing user actions and links to pictures.

Figure 8: StoryTable has a tangible interface to record, play and share video clips captured with the local camera.

not only saw but experienced using the videoProbe in their homes, they were able to incorporate the concept into their designs. In one exercise, families were asked to create a screenplay based on recent events in their lives. One family built their film around one of the video sequences taken from the videoProbe, and explored unpredicted situations, such as when a pillow fight accidently turns the camera away or when an explicitly-erased image is seen by someone in the other household.

One of our goals for videoProbe was that it would be open to interpretation by the family members. As described earlier, family members explored a range of uses from explicitly taking pictures for the mother's homecoming, to taking advantage of candid shots in the New Year's party to discovering otherwise forgotten events like the grandmother's visit. The teenagers in one family quickly discovered that videoProbe could be used to share handwritten notes as well as images. The first such note was written by a teenage daughter, who told her cousin that they were suddenly off on vacation for the week.

VideoProbe taught us a great deal about technology probes and how to develop them. MirrorSpace[16] explores an intimate form of communication that is specifically designed to provide open access while protecting privacy in a way not possible with videoProbe. What initially looks like a mirror is actually a screen that displays the overlaid images of each person approaching the MirrorSpace. Another technology probe, tableProbe[12], provides a tangible card interface with RFID tags to collaborate on editing shared videos. It was inspired by a combination of MirrorSpace, which exchanges video, and the 'day-in-the-life' videos generated by videoProbe. TableProbe provides a lightweight way to create videoclips captured live and share them, even if dislocated in time. Finally, the idea for storyTable came from a father and his 12-year-old daughter when they saw tableProbe, which reminded them of the puppet theater in her room. So we created StoryTable for her and installed it in her bedroom (Figure 8).

4.3 Testing in the real world

Installing the videoProbes and maintaing them proved to be a major challenge. We faced a variety of problems, ranging from network providers unexpectedly shutting down connections to family members who liked to fiddle with the system and accidently disconnect it. Once the videoProbes were working and in regular use by the family members, we were able to evaluate particular design features.

VideoProbe was primarily designed to capture images and for this, the interface worked very well. However, if one wanted to make a commercial version, it would be necessary to improve the design of the shared photo album. The current interface is too simple to be really useful and needs a better method of managing pictures. It would also need to support sharing of images to the outside world. A key advantage of videoProbe is that users need not explicitly identify who will see the images: they are automatically shared among the pre-specified family groups. But from time to time, users want the ability to extract a particular image and send it to someone outside the local network. For example, the first family wanted to send their New Year's Eve images to friends who had attended. VideoProbe was effective as a technology probe in identifying this design problem.

Another interesting feature of videoProbe is that it takes shots of situations that would otherwise be considered unimportant. For example, we installed videoProbe in our own homes and a shot was taken of one of the authors feeding his baby. When he demonstrated videoProbe to his mother, she complained that this was just the sort of picture she really wanted. Such pictures are rarely taken because they are either deemed too mundane or require someone else to take them. Yet having these pictures helps remote family members feel closer.

It may be tempting for designers to add all the functionality that users request, even at the expense of making the interface more complex and thus less likely to be used. A better strategy is to provide more functionality through the existing interaction. For example, holding down the navigation button effectively creates a "day-in-the-life" video clip and is better than a separate "create video clip" button. In the current implementation, camera mode is autonomous, making it possible but not necessary for users to intentionally interact with the system. However, brower mode requires explicit interaction to navigate and save images. We could, in fact, make the browser automous as well. For example, recent images could appear in a slideshow loop or as time-lapse video clips. Combined with a proximity sensor, as in MirrorSpace, space could be divided into three ranges: a camera range, for taking pictures when the user is close, a viewing range, for seeing the day's images from a few feet away, and a privacy range, in which images are not taken.. This would address the privacy and browsing concerns identified above.

5. DISCUSSION

Our experience with the families and their videoProbes had a profound effect on our thinking about technology to support inter-family communication. We were fortunate to begin the interLiving project with a very open design brief, in which identifying the problem was as much a part of the research agenda as providing a specific solution. This allowed us to evolve our ideas over time. The technology probes, particularly videoProbe, provided a set of insights about family communication, novel design possibilities, and the technical requirements for an architecture to support them.

We originally expected that the follow-on to videoProbe would be a more complex technology. Instead, we discovered that single-function technologies that suport communication, like videoProbe and messageProbe, but also MirrorSpace, tableProbe and storyTable, are useful and appreciated in their own right. The families were satisfied with phones and, in some cases, electronic mail, but they expressed a desire for a different form of communication device that would be always "on" and let them share day-to-day information without explicit interaction.

VideoProbe became our prototypical example of a new class of technology, which we call communication appliances. We define communication appliances as simple-to-use, single-function devices that let people communicate, passively or actively, via some medium, with one or more remotely-located friends or family. Shared information might include sound, images, video, text or even touch. The desired style of connection may range from focused, synchronous contact to peripheral awareness of one another. Communication can occur over a distance, to other households or places, or over time. Communication can also occur over time, from leaving quick notes for oneself to preserving memories over years.

We see communication appliances as fitting what Weiser & Brown refer to as *calm technology*[18], which engage "both the center and the periphery of our attention, and in fact move back and forth between the two". An aesthetically pleasing example of a communication applicance is Strong & Gaver's feather[17], which jumps into the air and wafts gently earthward whenever a physically-distant loved one views a photograph of the feather's owner. Digital Family Portraits[13] obtain sensor information from a remote senior house and present it as a "qualitative reflection of his or her activity level". In[9], Hindus et al. describe prototypes that let lovers carry or wear a small token that glows if the remote token is touched, and a distributed decorative object that, upon sensing activity in the remote location, glows more or less brightly according to the level of movement. HandJive[4] lets remote users play together. If one physical moves a ball in one location, the distant ball moves as well. Heart2Heart[7] allows two people wearing digitally-enhanced vests to exchange a "remote embrace" using touch to wirelessly convey heat, pressure, and hearbeats.

However, the difficulties we had installing videoProbe in the families' homes led us to another insight, explaining at least part of the reason why such technologies have never left the lab and moved into the marketplace. Although some videoProbe problems were technical and could be resolved by advances in technology and service, others remain unaddressed. A key missing element is that family members have no easy way to specify who they want to connect their communication appliances with. If we create extremely simple, single-function appliances, we cannot also add a complex interface for managing an on-line network. Solutions such as telephone numbers, URLs and email addresses require access to another device and require the user to continually respecify who they want to link to. Addressing this problem is the focus of our future research.

6. RELATED WORK

The problem of shared awareness over a distance has been addressed at length in the research literature, particularly in the context of mediaspaces (see[11] for an overview). For example, Portholes[2] provides group awareness over a distributed workspace by broadcasting office pictures taken at regular intervals. However, unlike videoProbe, triggering is periodic, and is not related to interesting events. The function of videoProbe resembles that of ambient displays[13], which display information in the background without explicit interaction. However, videoProbe requires more interaction, especially while browsing images. Ceiva[1] is a picture frame that automatically downloads pictures sent by users using a web site. It does not take pictures by itself, and pictures are not implicitly shared by a group of users, they must sent explicitly to individual receivers using a web-based interface. This type of interface is not adequate to the kind of implicit and opportunistic communication that videoProbe supports.

On the design side, technology probes are similar to cultural probes[5] - kits of materials such as disposable cameras and diaries meant to inspire people and help them reflect on their lives in different ways. A number of researchers, including ourselves, have used cultural probes to elicit both design inspiration for new domestic technologies and information about the users of such technologies[8, 19]. However, cultural probes tend to involve a single activity at a particular time and are not necessarily technologies themselves. The Placebo Project[3] is closer to the concept of a technology probe: they introduce thought-provoking technologies into people's homes for periods of time. However, they do not use the technology to collect data about its own use.

7. CONCLUSION

In conclusion, videoProbe successfully provided us with information from three different perspectives: As social scientists, we obtained diverse and specific data about the families and greatly increased our understanding of them. As participatory designers, videoProbe successfully sparked ideas from us and the family members, influencing the design of subsequent technology probes and prototypes, but also providing a framework for thinking about a new category of technology, communication appliances. Finally, as engineers, being forced to install and maintain videoProbes in the families' homes led us to a deeper understanding of the architecture requirements for this new kind of technology.

VideoProbe showed us that it is indeed possible to combine research methods from different disciplines in the same study, if we consciously address the different goals they serve. VideoProbe was also a key inspiration for our current and future work, which involves the design of both the technical infrastructure and the creation of additional communication appliances.

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