Studies of Co-designed Prototypes in Family Context

Deliverable 1.3 & 2.3 • 2004-02-09

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interLiving deliverable D1.3 & 2.3

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Introduction

This the third and last year deliverable from the interLiving project, “Designing Interactive, Intergenerational Interfaces for Living Together”, within the EU FET Disappearing Computer initiative.

Integrated report

In the interLiving project the research process is strongly cooperative and multi-disciplinary with participants with background in ethnography, computer science, graphic design, industrial design and interaction design. This cooperation has become very strong as a natural way of working in the project and that should be expressed also in the account of the experiences and achievements of the project.

Thus we have chosen to “melt” the originally planned two deliverables:
D1.3 Co-design - Results of usability studies and qualitative evaluations of the prototypes
D2.3 Technology deployment - Working prototypes of the new technologies co-designed with family partners into this integrated report,
D1.3&2.3 Studies of Co-designed Prototypes in Family Context.

This written report is accompanied by video material, on a DVD.

Contents based on papers, published and under submission

The project has in its third year reached a phase of extensive publication and dissemination of results at scientific conferences and exhibitions.
This deliverable contains:

- 6 papers published at conferences in 2003.
- 1 paper accepted for Pervasive’04
- 1 paper submitted to DIS’04
- 1 paper submitted to HCI’04
- 1 workshop submitted to CHI’2004
- 4 papers under preparation for submission
- 1 manual of the FamilyNet prototype

The papers are reprinted sectionwise, after overview introductions.

The first section contains papers on *Design and Methods*. It is divided into the following four sub themes.

1.1. *Cooperative design* (5 papers), on the methods we have developed and used for cooperation with the family partners and the teams of researchers and developers from several disciplines.

1.2 *Understanding connected living together* (1 paper), on understanding based on artefacts for life in the connected home.

1.3. *Interactive thread* (1 paper), on a collection of methods for fast involvement of a gathering of potential users, e.g. a conference, in design considerations for getting ideas and material.

1.4. *Technology Probes* (2 papers), on probe methods for getting user information and to inspire users and designers to new ideas.

The second section contains papers on three *prototypes* developed during the third year of the project in a cooperative iterative design with the families. They are different distributed shared surfaces:

2.1. *Mirror Space* (1 paper), a distributed interactive video connection between households.

2.2. *Disappearing Ink – InkPad* (2 papers), a distributed note-pad with possibility to make notes temporary, recurring, etc.

2.3. *Shared Family Calendar* (1 paper), a shared calendar between households.

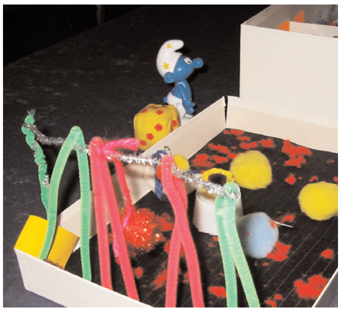
The third section contains a conclusive discussion and a paper about possible use and further development of the FamilyNet prototype.

3.1. Results and shortcomings

3.2 Technology development with design method influence

3.2. Follow-up: FamilyNet

1. Design and Methods



Paper section 1.
Design and Methods

In this section we give account of the design methods and other methods practiced, developed and experienced in the project, as matured and published in year 3.

1.1 Cooperative design

Basic methods for understanding and involving the family members in the idea generation, design and development of communication prototypes are based on the cooperative / participatory design tradition. The first paper presents the experience of designing for and with families. The second paper takes that a bit further, also discussing the cooperation in the multidisciplinary research team. The third paper discusses how to educate for these multidisciplinary situations. The fourth uses the interLiving experience as a basis for recommending "Agile design" in a similar way as "Agile/extreme programming", i.e. working in multidisciplinary teams in all activities, sharing experience in field-studies, in design sessions, in program development.
The fifth publication is a position paper on the interdisciplinary design expersience from interLiving.

1.1.1. Westerlund – Lindqvist – Mackay - Sundblad: Co-design methods for designing with and for families, presented at EAD'03, Barcelona, April 2003, 10 pp.

1.1.2. Westerlund – Lindqvist – Sundblad: Co-designing with and for families, presented at COST 269 conference - User aspects of ICTs: good | bad | irrelevant, Helsinki, September 2003, pp.290-294.

1.1.3. Mackay: Educating Multi-disciplinary Design Teams, presented at Tales of the disappearing computer, Santorini, June 2003, pp.105-117.

1.1.4. Sundblad – Linqvist – Westerlund – Eiderbäck: Agile design of interactive systems. Submitted to DIS´04, Boston, August 2004.

1.1.5 Westerlund – Lindquist – Sundblad: interLiving: a multi-disciplinary cooperative design approach, submission to CHI2004 workshop on exploring the relationsship between design and HCI, Vienna, April 2004.

1.2 Understanding connected lives

Through building appliances for physical communication further understanding can be gained on the way that individuals might live with always on communication appliances that connect remote homes together. In the paper a series of such appliances (artefacts) are described and discussed from this aspect of understanding.

1.2.1. Evans – Hansen: Reverse Archaeology: Designing artefacts for life in the connected home. Draft version to be submitted.

1.3 Interactive thread

The method of Interactive thread takes advantage of gatherings of people for their contributing user aspects and design skill to our development of technologies for families. It was invented within interLiving and used first at DIS'2002 and then on several larger and smaller occasions. The method also encourages participants to collaborate in an interactive event and to share and discuss our methods. The paper describes the event at the Tales of the Disappearing Computer conference.

1.3.1. Mackay – Evans – Hansen – Dachary – Gaudron, N.: Weaving the Interactive Thread: An Interactive Event for the Tales of the disappearing computer, Santorini, June 2003, pp. 409-415.

1.4 Technology Probes

Technology Probes are a set of easy-to-use, distributed shared surface technologies that we installed in the households to understand how technology is used in a real world setting and to inspire users and designers to new ideas. The main purpose is to understand and get ideas, not to evaluate and improve the probe device (in contrast to a prototype).

The paper 1.2.1 on "Understanding connected lives" contains an audio connection device between households for "knocking", that has the probing qualities.

Of the papers in the current section the first describes and draws conclusions mainly from the MessageProbe, message pads connected between households for online sharing of messages. The second paper mainly deals with the VideoProbe, video connection between household for exchanging live images. Both probes were mainly developed in years 1 and 2 of interLiving and are extensively described in deliverable D1.2&2.2. Use experience with the probes has continued into year 3, partly because of delays due to unreliable network providers.

1.4.1. Hutchinson – Mackay – Westerlund – Bederson – Druin – Plaisant – Beaudouin-Lafon – Conversy – Evans – Hansen – Roussel – Eiderbäck – Lindquist – Sundblad: Technology Probes: Inspiring Design for and with Families, Proceedings CHI'2003, Fort Lauderdale, April 2003, pp. 17-24.

1.4.2 Conversy – Mackay – Beauduin-Lafon – Roussel:
Video Probe,Submitted to HCI'04.

Co-design methods for designing with and for families

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ABSTRACT

This paper describes co-operative design work regarding the development of IT artefacts to be used for communicating within families. It shows advantages of co-designing together with users. Thereby obtaining 'real life' experience, understanding and knowledge about their needs and desires.

Since there was no specific solution or technology in mind from the beginning, several different methods were used in combination to investigate what had meaning to the family members. Some of the methods used are: cultural probes, interviews, observations, workshops, video brainstorming, prototyping in the homes, technology probes and individual assignments.

The researchers represent different academic professions, mainly ethnography, industrial design, interaction design, computer science. To minimize the problem of 'handing over' information, researchers from at least two different backgrounds participate in all work done together with the families.

KEYWORDS

Co-operative design, industrial design, families, domestic environment, process, methods, probes, workshops, IT, ethnography,

INTRODUCTION

This paper describes co-operative design work regarding the development of IT artefacts in Sweden within the interLiving project. interLiving is a three year project, 2001-2003, funded by the EU Future and Emerging Technologies, initiative the Disappearing Computer. The research is conducted both in Stockholm, Sweden and in Paris, France. The group of researchers are from many different disciplines, ethnography, psychology, computer science, industrial design, interaction design, etc.

One of interLiving's objectives is to develop artefacts that use information technology to facilitate intergenerational communication within families.

There was no specific problem, solution or technology in mind from the beginning. How could we find out what to do? How could we get hold of the design ideas that would be reasonable to develop?

Another of our objectives is to try out, modify and describe different methods for co-designing with persons in such a 'private' setting. We want to develop methods that let the family members participate and influence the design through out the whole process.

We use the concept of 'family' to describe close relations spread over generations. The three Swedish families we work with are distributed in three households each. The participants' ages varied between one and 75 years. We will work with the same 30 people throughout the three years.

The researchers in Paris also work with three families.

The focus in this paper is on the strategies and methods we use from an industrial design point of view.

Figure 1. "Mother seeking children. Come in and eat!!!" A photo describing some of the complexities of family life. It is taken by family members as a part of the probe method, see below.

Presented at the 5th European Academy of Design Conference, Techné: The design wisdom. Barcelona, 28, 29 & 30 April 2003. http://www.ub.es/5ead/

Published in proceedings and book of abstracts.

BACKGROUND

The last decade there has been a growing interest in technology used in a nonintrusive way. 1991 Mark Weiser coined the term 'ubiquitous computing' in an often referred article (Weiser, 1991). 1995 'The Vision of the Future project was initiated within Philips to explore how future products may be in ten years time.' (Lambourne, 1997: 494) This was an interesting project that had designers in the core team. One strength of Philips' project was the effort put into the visualisation of the ideas.

Other descriptions of this development is Donald Norman's The invisible Computer (Norman, 1998) and the EU Disappearing Computer research initiative.

In Sweden there is a strong tradition of participatory design both in the field of industrial design and in software development. The Utopia project from the beginning of the 1980's is an early seminal example (Bødker, et al. 1987, 2000) where the key ideas were developed. The company Ergonomidesign has designed products together with and for disabled people and for workers since the seventies.

There are of course big differences between how the participation is carried out in different areas and as within different projects. Work related aspects have been in focus although projects such as KidStory (Benford, et al, 2000) shows that the ideas also work in other settings, here with elementary school children.

The growing interest in IT technology for domestic environments and family contexts is shown in frequent workshops, e.g. Equator 2001 and CHI 2002, to which we contributed.

OUR APPROACH

DESIGN PERSPECTIVE

One of objectives is to design information technology artefacts that will be used for a length of time by the family members. From a design perspective it is natural to consider all the meanings the users put into an artefact in its changing future contexts. This is done from the very beginning of the development process.

Some disciplines tend to focus mostly to the operational aspects of artefacts, the 'task solving' and seem to describe artefacts as objects with a single predefined purpose. This would imply that a radio is 'used' for listening to audio broadcasts, a chair is 'used' for sitting.

But even a simple artefact like a key chain has great symbolic value and we have different strategies for using one or several in order to sculpt the boundaries between home and work (Nippert-Eng, 1995: 48).

A chair also has a wider purpose than it's operational aspects. It has meanings even when it is empty. It has presence in the room that interacts with other objects and people. It shows or affords us the possibility to sit down in it. Although a chair could be purchased for its sitting qualities it is most certainly chosen either for its appearance and/or price. Planning and rearranging furniture at home is a design activity that almost everybody is involved in sometimes (Heskett, 2002).

It is not possible to generalise and please 'everybody' with one artefact. People put meaning into artefacts in manners that are very personal. (Csikszentmihalyi, 1991) The following quote from a recent Computer-

Figure 2 and 3. Two kitchens with different characters. Probe photos

Figure 5 (above). The vases were described as 'nice vases' by Hanna. She had got them as a birthday present from her sisters and parents. Her husband Thomas did not like them. Probe photo.

Figure 4 (left). 'Thomas had bought a whole body mirror cheap at one of "our" antique dealers on "our" street. Just the kind I wanted to have – Really nice I thought! 50's. I'll take a picture.' Probe photo and translated text from diary.

Human Interaction paper reveals the common misunderstanding that there is an absolute measurement of beauty. They miss that peoples preferences depend on factors like: class, cultural background, economic background, ethnicity, gender, age, neighbourhood, occupation, etc.

'The visualization should be aesthetically pleasing, a typical home decoration.' (Mynatt, et al. 2001: 336)

Figure 2 and 3 are photos of two different kitchens. The different owners have expressed that they have a nice kitchen. The artefacts are presumably chosen and arranged with great care. The pictures show that the styles and characters (Janlert, et al, 1997) differ between the kitchens. The owners would probably not agree to switch any single artefact between the kitchens.

Many of the artefacts that we choose to surround ourselves with function as signs. The mirror shown in figure 4 might signal that the people living here are conscious of style and interested in design.

The way people relate to artefacts is constantly changing. Time and context give artefacts their value. Used things get thrown away and may end up in a antique store or at a flea market as a valuable artefact.

Within a family there are always objects that have different roles and meaning to different members. This adds more complexity.

This implies that there are more aspects than solving the task to consider while designing for domestic environments. In this context the users seem to regard aesthetics as very meaningful.

Many of the methods normally used for Human Computer Interaction related research have been developed for studying working environments and are therefore mainly task oriented and focused on productivity. The interLiving project needs to develop an approach that used methods that helped us understand what has meaning to people in their complex situation and context.

MEANING, NEED AND DESIRE

In everyday speech the concepts 'use' and 'function' are often related to activity. You would not normally say that you use a painting that you have hanging on the wall. The concept of function has a wider meaning to designers, letting it cover all meanings an artefact has to its users. That means covering social, cultural and operational meanings. The method 'functional analysis' is used to describe all the needed and desired aspects of an artefact. (Löwgren, 1999. Westerlund, 2002) This meaning of function is similar to Donald Norman's (and Gibson's) use of the term 'affordance'.

... 'affordance refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used' (Norman 1988: 9)

(For an extended discussion about 'affordance' see Norman (1988) and Gibson (1982). Read Heskett (2002:

36ff) and Westerlund (2002) for further discussions on the concept of 'function' in this context.)

We had to find a way of setting our design problem together with the families. Although problem setting is a natural part of design, the amount of freedom or uncertainty in interLiving was extreme. Our roughly outlined design space was to use information technology to facilitate intergenerational communication within families. The problem setting that usually is done during a design process goes hand in hand with problem solving as a way of learning about aspects of the future situation of use. Problem setting is discussed by Schön 1993: 18.

'And the activity of problem setting becomes an inquiry into this purpose, in order to understand what it is. Thus also the task of problem setting makes a contribution to the designer's understanding.' (Gedenryd, 1998: 83)

What should we try to find in our studies? It could be a 'problem', it could be 'need', i.e. trying to find something that is lacking or something that is important and which can be improved. But since we also realize that family life is not only a unit for physical survival we also tried too look for potential and actual 'desires'. Needs and desires are concepts that often are used as goals for artefacts. They can both be regarded as meaningful. From a product semantic point of view it is natural to look for 'meaning'. Klaus Krippendorff writes:

'Design concerns itself with the meanings artifacts can aquire by their users.' (Krippendorff, 1995: 153)

The concept of 'meaning' seems to work well even in this project and definitely better than 'use'. It is an important distinction that the meanings an artefact has, are constructed by its user(s). This fits well with our approach of working closely together with families. From an industrial design aspect we realize that if something is to be regarded as meaningful it has to be designed and consciously shaped in order to have an expression and character that will both ease the operation and also fit into the existing environments. Therefore it will be crucial to get inspiration from as real and concrete situations and environments as possible.

It is important to keep in mind that these different concepts let us describe and reflect on the world seen through different models. Models are used for emphasizing some aspects and suppressing others. This is very useful and revealing, but we must be careful because they do not describe all of the real life situation.

METHODS

There are of course many different ways to go about and no approach can guarantee success. Little is actually known about where, why and when the ideas that lead to successful solutions appear. We know that it is difficult for users to be innovative by just talking about what technology they want in the future. But on the other hand people can be very innovative when they are given the right tools and circumstances.

Our approach is to use several different methods in trying to get to know the family members different needs and desires. This approach is called triangulation. (Mackay, 1997) We calculate that what does not show in one method will be revealed in another. And strong aspects would have impact on the findings from the use of several different methods. We decided to use cultural probes, workshops, observations and interviews. Of course prototyping will be included as well. The workshops include the use of several different methods, which is described more below. After some time we also developed Technology Probes which are complementing Cultural Probes, see interLiving deliverable 1.2 & 2.2, 2002, Brown, et al, 2001 and Hutchinson, et al, 2003. These are scaled down, feature slimmed applications that are on their way to become disappearing computers in the sense that 'we [are] freed to use them without thinking and so to focus beyond them on new goals' (Weiser, 1991: 933). They give us interesting information about the families use of technology.

Process

Since understanding from different aspects is a necessary ingredient we need to work with researchers from several different academic professions together in all events. The probes were discussed and analysed this way. The interviews are done by an ethnographer and an industrial designer together. And the prototyping work done in the families homes is conducted by these two and a computer scientist. We work closely together and minimize the usual sequential way where one person hands over the results to the people in charge of the 'next step'. The result of this was a greater depth of the investigated aspects and also in a better, and mutual, understanding. We work together even during other phases, planning, workshops, etc. This gives us all the "same" experience about the three diverse families. We make a common ground to work together from in the development.

There were several sources of inspiration for this, partly experience from our own practice and horror stories about the lack of results from the 'waterfall' or 'toss it over the wall' way of working. We were also inspired by Henrik Gedenryd who stresses that 'design cannot be separated into stages.' (Gedenryd, 1998: 69)

Figure 6. A probe photo of 'nice' stuff.

Figure 7. Probe photo of 'ugly' stuff.

Probes
Cultural Probes is a new method used in research developed by Bill Gaver and some of his colleagues at the Royal College of Arts during the Presence project. (Gaver, et al, 1999)

The main idea behind Cultural Probes is to get inspired and informed. A probe or kit of probes is handed to the person(s) that you want to learn about. After they have completed them, they send the results to the researchers.

In our use of the Probes it is central to involve the users also by discussing the feedback from them to find out more about their situation, desires and needs.

We designed and produced kits of probes. Each of our households got one kit. The kits were produced so that all the contents would have an integrated appearance. It was important that they gave the users a notion of importance and respect. The 'questions' and tasks were very open-ended and we hoped that there would be some unexpected results. We tried to make the probes so that all family members, from one to 73 years old, could contribute. There were plastic pockets to encourage and make it easier for people to collect and send us things.

The kit also contained a diary that they should write in during a period of two weeks and repackaged, disposable cameras with questions printed on them. We framed the photo probe with three assignments:
'Take photos of:
places where you leave messages to the others,
things that remind you of the others in your family and
things that you find pretty or ugly in your home.'

The purpose of the probe photos was to encourage family members to take pictures of their home environment, emphasizing communication places, artefacts and aesthetics. We want them to reveal to us where and how they find a communication through an artefact meaningful and start a dialogue about aesthetics.

We wanted spontaneous reactions but we also wanted the people to reflect afterwards on the photos and why they took them. Therefore we had arranged so that the developed photos were sent back to the families for annotating. And after doing that the families sent them to us.

The probe photos that were sent to us from the different households had some similarities. Most of the photos of things that were considered 'nice' were simply interiors in their homes.

People have a hard time making technology fit into their life. Most other things in a household are there because they are experienced as meaningful.

Probe diaries
Our probe diaries were interesting for several reasons. We often got several views on the same situation. One Friday Hanna reflected over calling her mother Barbro. But she decided to call the next day instead because she wanted to talk for a long time. In Barbro's diary she wrote that she had thought of calling Hanna the same Friday but decided to wait until Saturday. The reason for this was that she felt that they had a lot to talk about.

The diary probe is a good tool for revealing stories like the one above. This information would be hard to get with other methods. Since it is about non-communication.

The probes gave us insight into the families, but mostly from a few peoples view. Head of family = head of probe! We needed a better way of letting everyone express themselves. To the smallest children, 3,5 and 1,5 years old, we made the probes as easy as possible to handle and relate to. We gave them a Polaroid camera and asked them to take pictures of things they want

Figure 8. Fighting brothers. These probes focused on making them visible in the process. From the children's video assignments.

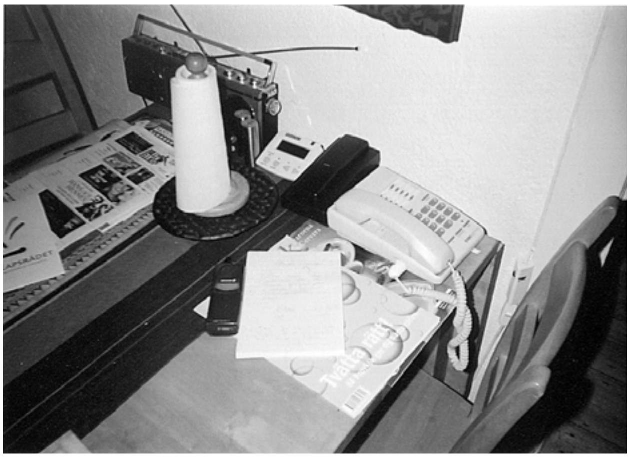


Figure 9. The green grandparents kitchen table with portable phone and other devices. Probe photo.

to show to someone in their family. The photos were put into a photo album and their parents annotated them with the children's stories.

The older children, 9 to 14 years old, were lent a simple digital video camera with the assignment to: Describe everyday activities to somebody from outer space that understands your language.

The grandparents Calle and Marianne made a video describing how they used their collections of photos. Photos of grandchildren and events are important in their home.

This way we achieved both more interest in the project and a better understanding of the children's everyday life.

It is clear that the probes have revealed a lot of information about the complexity and the context seen from the users perspective. The probes also help expanding design space.

Interviews
A couple of weeks after the probe kits were handed out, the probe photos and diaries started to arrive back to us. We also got a couple of postcards and a few other artefacts the families had collected. After studying the photos and reading the diaries we made interviews in each household. The idea was to get more information about matters that were presented through the probes.

One woman explained how important she thought it was for her to have really nice looking technical artefacts, like an iMac on her desk at home and a neat mobile phone in her handbag. She very seldom used the mobile phone in public. Just knowing it was there and nice looking was good enough for her.

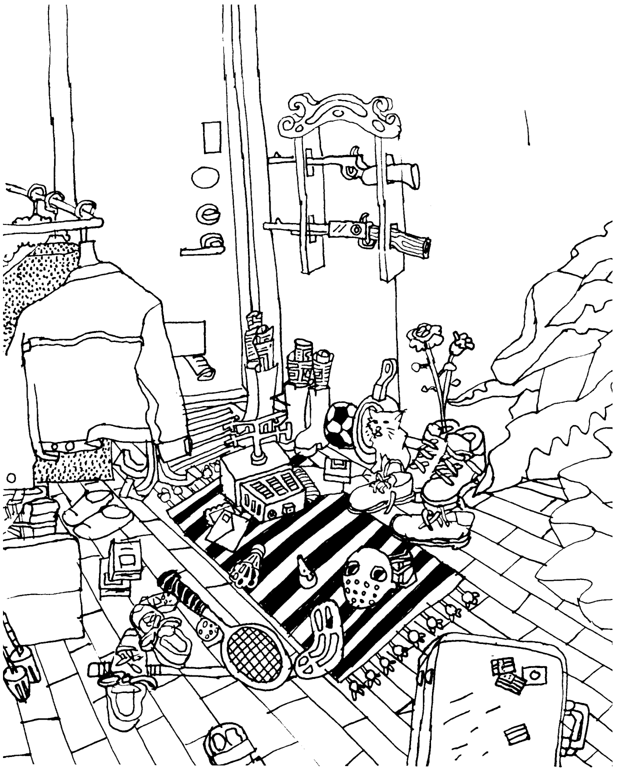
One household took a photo of their portable phone and wrote that is was 'ugly'. (Figure 9) In the interview they explained that it had sloppy forms and did not fit into the character of their house. They had several Bang & Olufsen products. At an interview a year after, they told us that they had convinced themselves that the sound was not good enough and had bought a new portable phone. When they described their shopping it was clear that they had a holistic view of the artefact. They reflected on sound quality, aesthetics, battery life and the character at the same time.

Questions about specific events that were written in the diaries often led to discussions about the asymmetries in communications. Often one of the people speaking have more time and is more interested in a longer conversation, while the other party just wants to exchange a few words. The following comparison with the situation when you are in the same room was made.

'You can tell by the way a person is reading the newspaper if it is OK to open a conversation or not. Perhaps a glance over the top of the paper says: "Sure, go ahead".'

Overall, technology was primarily seen as a means for facilitating seeing each other in person. Meals with the whole family were really desirable.

Workshops
Most of the big workshops are held in our lab where we have a large room that gives place for the around 30 people that participated. They are hands-on design exercises in four to five steps. The workshops are carried out on weekends and last around five hours including lunch.



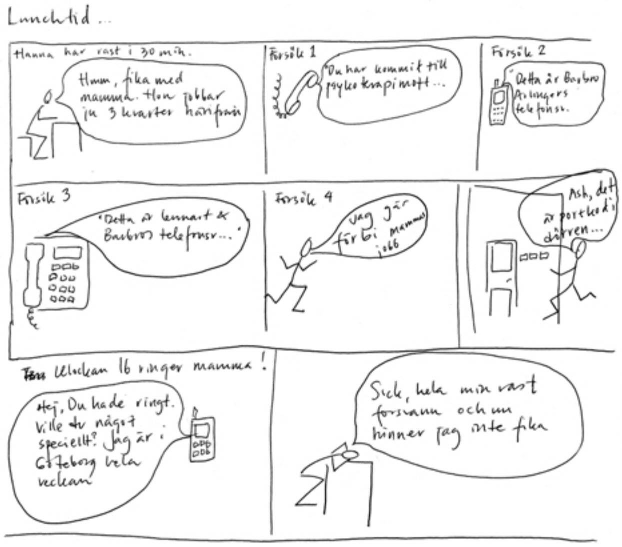


Figure 11 (above). A storyboard showing problems getting in touch for lunch. From workshop.

Figure 10 (left). One of 17 drawings that were used to inspire and frame the work in one of the family workshops. Henrik Färlin made them.

One objective with the workshops is to help the family members generate and develop design ideas that they experience as meaningful. We start the workshop activities by introducing something that frames or focuses the work. This is not done so much verbally as visually, like showing video clips from interviews with the households.

One workshop started with a stack of 17 drawings. One is shown in figure 10. Each drawing was inspired by a list of quotes from what the family members had spoken about earlier in the project. The drawings can actually be seen as a form of analysis and synthesises of these quotes. These drawings framed the work into these areas but also opened up for reinterpretations.

This feedback gives all participants the opportunity to correct or verify our descriptions. This also gives the different families understandings of the other participating families.

After this introduction the workshops usually continue with a "use scenario". This is often developed with the help of critical incident technique where the participants express something real and recent that has had some meaning to them. (figure 11) It could have been something problematic, a breakdown or it could be something nice that had happened to them. Usually this should have to do with some type of communication with others. All this helps keeping the work relevant to and reflecting their real life, expressing real needs and desires.

The third step concerns the generation of ideas. Normally a shorter brainstorming is followed by everybody sharing their ideas.

The fourth and longest part is where the groups use one or more of the design ideas to change the use scenario into a better working scenario, a design scenario. Here they do design work, make decisions and contracting the design space.

It is important that they show us how they want things to work, how they interact with the artefact and in what context. Therefore we asked the groups to build simple low-tech prototypes of material that we supply. The members of the group may act out the scenario with the help of the prototype. Sometimes this step is presented as a video prototype, the acting out is recorded on video, (Mackay, 2000) other times as a series of photos.

Of course a lot of exchange of ideas takes place in language. This is inevitable. But for several reasons we try to move the discussions into artefacts of some kind. This makes it easier to involve people of all ages. And developing 'beyond' spoken language forces the ideas to be more precisely described. When a course of events is shown, all the necessary interaction also has to be figured out and the scenarios contain more details. Both the design idea and the contexts are described better.

Finally all groups present their design scenarios and we all reflect on them. At one of the early workshops The

Figure 12. A low tech prototype shown in relevant contexts with the help of Polaroid photos. From workshop.

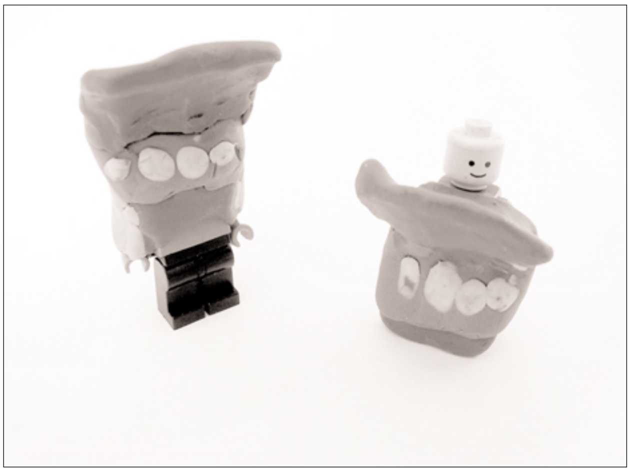


Figure 13. The Bongo fax. From workshop.

fathers and mothers were the most active and suggested family wide control systems. One of the boys build a model of a teleporting device, the BongoFax (figure 13), that could be regarded as an escape machine. The control that the parents found meaningful to have over their children's location and homework status had no correspondence in the children's world.

Prototyping (low-tech)

The future use of the eventual artefacts is in focus during most of the work but we also work directly with prototypes in the families homes. We install low–tech prototypes that are 'used' for some weeks. Following that we have workshops in the homes reflecting on the result. This step naturally gives us a lot of specific information about the use and context.

'The practitioner allows himself to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomenon before him, and on the prior understandings which have been implicit in his behaviour. He carries out an experiment which serves to generate both a new understanding of the phenomenon and a change in the situation.' (Schön 1983: 68)

FUTURE WORK

When the prototypes have evolved so that they work well in the specific contexts in the households we want them to be used for at least six months in order to get a deeper understanding of how the meanings the different people find in them change. We will then widen the group of users to investigate how general the meanings are.

The real validation of this work will be done in use.

CONCLUSIONS

Our intention in the beginning of the project was to get design ideas from the families through the probe and workshop artefacts. But it turned out to be more of a continuous process where we gradually developed an understanding of what was meaningful to the different people. That helped us frame the subsequent activities into exploring this further and eventually narrowing design space into a couple of design ideas.

The ideas that have been generated in cooperation with the family members concern coordination and playful interaction. These will be developed further by prototyping together with them to assure that they continue to have meaning to them.

We have also learned the importance of the non symmetric aspects in communication.

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NOTES

The names of the family members are not their real and we are glad to have everybody's permission to publish the research.

Figure 14. Low-tech prototypes of rings for staying in touch through puffs of air. From workshop.

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Co-designing with and for families

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Abstract: To develop technology for families we need to shift perspective from the more common technology development for domestic environments or the smart home. We believe that to develop and design useful technology we have to understand what families' needs and desires are. This paper describes some aspects of the co-operative work within the research project, interLiving.

The interLiving project, "Designing Interactive Intergenerational Interfaces for Living Together", is funded by the European Union as part of the Disappearing Computer initiative. The three-year project aims to study and develop, together with families, technologies that facilitate communication between generations of family members living in different households.

interLiving builds on the Scandinavian design tradition and is multidisciplinary with researchers from computer science, ethnography, industrial design and psychology. The participants represent different ways to conduct research, design and technology development work. We use combinations of diverse collaborative methods like workshops, cultural probes, technology probes, interviews, prototypes, etc. Also, researchers and users work closely together throughout the whole design process.

In this paper we will focus on users as individuals leading their every day lives and through that give us input to the design process. How are design decisions taken, which are taken and why?

KEYWORDS
Communication, Families, Multidisciplinary Design, Co-operative Design, Collaborative Design, Participatory Design, Ethnographic Studies, Industrial Design, Design process, Design methods, Technology Probes,

INTRODUCTION

BACKGROUND

In academia and in industry there are many projects that are focusing on technology in domestic spaces and the Smart home like the Casablanca project (Hindus, 2001) and 3Com's Audry (Smith, 2000). None of these are available on the market today though. Many of these technologies are developed by technicians or researchers and for people with similar lives, surrounded by technology, always up to date, competent on handling new technology, travel a lot, have a huge IN-box, etc.

Even so, the aims with these technologies are often well meant. They are developed to help people do everyday tasks, like shopping, washing or looking after your elderly folks, to lead your life more efficient and easier. The solutions are very often "techy" both in functionality and appearance.

You can, for example, track your children with help of their mobile phones. To gain control in your life the technology helps you controlling other people in your surrounding. The control panel for booking the washing machine or configure the web-cam security scanning is a computer screen with all the features Microsoft software has. Does your children, or your old parents, want to be tracked so that you can feel at ease? Has a computer screen the ultimate appearance to be hung on the wall in your home? There are many questions that can be posed concerning technology in the home.

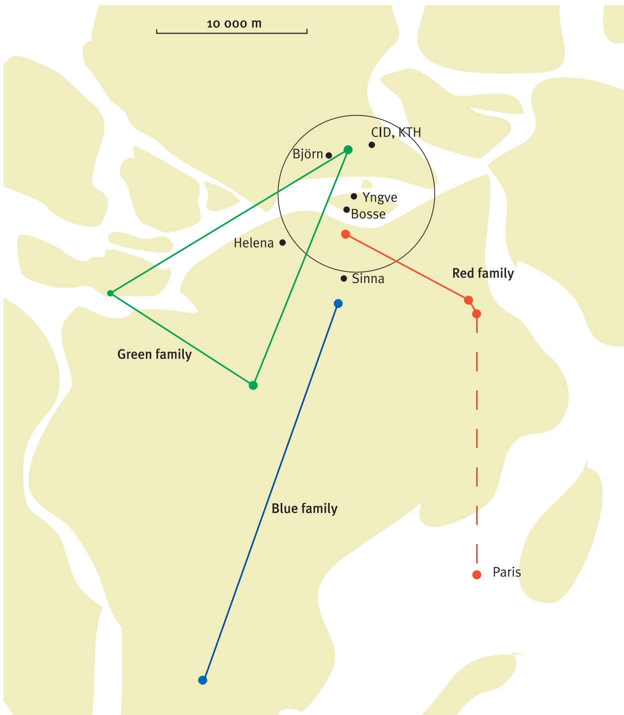

Fig.1 Map over Stockholm with the position of the households where our collaborating families live are represented. The researchers homes and our lab as well.

In this paper we will, by discussing some aspects of the research work in a project called interLiving, focus on what we think is a shift in perspective on technology for everyday usage, from designing technology for the domestic space to designing technology for individuals in their context.

INTERLIVING

interLiving, "Designing Interactive Intergenerational Interfaces for Living Together" is coordinated by CID (Centre for User Oriented IT-Design) at KTH (the Royal Institute of Technology) in Stockholm, Sweden. Partners are INRIA (Institut Nationale de Recherche en Informatique et Automatique) in Paris with Wendy Mackay as leading researcher there and LRI (Laboratoire de Recherche en Informatique Université de Paris-Sud) with Michel Bedouin-Lafont as head of the research team there. interLiving is funded for three years from 2001 by the EU IST FET research initiative "The Disappearing Computer".

We work together with three families in Sweden and three in France. This paper deals with the work done in Sweden but similar work is done in Paris by our two partner research labs.

interLiving builds on the Scandinavian design tradition and is multidisciplinary with researchers from computer science, ethnography, industrial design and psychology. The participants represent different ways to conduct research, design and technology development work. Also, in the EU FET (Future Emerging Technologies) research planning there is a strong awareness of the importance and value in bringing in end users as design and development partners (Wejchert, 2001).

Our hypothesis is that co-operative design is a successful approach. So, in January 2001 we put an add in Metro, a free Stockholm subway tabloid, searching for "Families to participate in research project about communication and new technology". The criteria were that they should consist of three generations and live in not more than two hours form Stockholm. We received 40 replies and chose three of those. The three participating families in Sweden consist of eight households spread out in the city, in the archipelago and in the countryside. They live both in apartments and houses.

We call the three families Red, Blue and Green. The youngest participant, when we started, was nine months and the oldest one seventy-two. To work with real families mean that we will co-design with individuals of different age, different skills, different wants and needs. A three-year project means also that we will co-design with the same people for three years. This means that their age, skills, wants and needs, perhaps, will change over time.

METHODS AND MULTIDISCIPLINARY DESIGN TEAM

interLiving has two related objectives: To develop novel and appreciated communication artefacts and to improve design methods.

But how do you do co-operative technology development with families? Depending on the users different age, skills, needs and desires we knew that we had to approach the individuals in different ways. You cannot make a four year old do the same things as a fourteen year old or a forty-four year old. By engaging the family members in several different methods and activities, we get to hear and see many different aspects of their life.

We strongly believe that co-operative design is a successful approach. In interLiving this means expanding this field from mainly dealing with work related matters into families. To understand the needs of families in their every day life, to develop innovative artefacts that support these needs and to understand the impact such technologies can have, we use combinations of diverse collaborative methods like workshops, cultural probes (Gaver et al., 1999), technology probes (Beaudouin-Lafon et al., 2001 & 2002), interviews, prototypes, etc. This approach is known as triangulation (Mackay, 1997). The methods are fully described in "Co-design methods for designing with and for families" (Westerlund et al., 2003).

Mixing and trying out methods is one way of approaching our group of users as individuals for design work. It is also a way of understanding how these methods can be improved. We want to investigate which ingredients from each method that are important during the development.

With co-operative design we also mean that the multidisciplinary research group, consisting of an industrial designer, a computer scientist and an ethnographer, should work closely together continuously during the whole project. There should be no "handing over information" between ethnographers and computer scientists for example. At least two from the research team should be present at every activity with the households.

Another important issue here is that we all, users and researchers, have experience of family life. We all belong to a family. Therefore, we are not striving for all design decisions necessarily to be made by the users. We have for example decided that we will not engage in any technology that has to do with surveillance. There is commercial technology available for that, and besides it has very little to do with communication within family life, even though some parents think it would be convenient.

DIFFERENT POINT OF VIEWS ON AVAILABLE TECHNOLOGY

Today some people say that, soon, when broadband is available to everybody and when everybody can to be connected all the time, people can work from home, check how their children are developing at the day care centre and shop through the Internet (Metakides et.al. 2003).

If that should be the ultimate goal for everybody, we need to know how that can happen, because technology does not just happen. We also need to know if being connected with the whole world all the time is what people want. What do we want to do with this kind of technology? In interLiving we experience a gap between some of these descriptions of technology and real peoples lives.

WORKING IN THEIR HOMES

We visit the households to do low-tech prototyping. On other visits we install technology. This often starts with setting up

Fig. 2 and 3 show two kitchens with different characters. Probe photos.

an ADSL connection and thereafter the technology probes and prototypes. For some households it took us more than two years before this was technically possible. All these activities take time, sometimes almost ridiculously long time. The good side of this is that it gives us more insight and other stories of the families' lives.

When the day for broadband installation eventually came for the Blue nuclear household, we drove to their house in the outskirts of Stockholm. The installation involved two grown up family members, one teenager, a computer scientist, an industrial designer, new network cards in the family's own computer, several phone calls to "support", etc. The scheduled one evening installation became two days. No one still knows why the installation did not work the first day. But one afternoon one of the sons happened to connect a telephone to an outlet that his parents didn't know of and then the ADSL connection started to work. And after that the ADSL works even without the extra phone connected. These kinds of time and effort consuming activities, is the reality for all of us, researchers as well as family members, when working with technology and the home.

ASYMMETRY

Also, many of our partners express a need to be left alone without someone being able to phone or access them all the time. The mother in Red family was very clear on that point. – "It is not everybody's right to be able to contact me all the time!" She has four children, the youngest was nine when the project started and the oldest was 21. She works full time and is family life head coordinator since her husband is travelling a lot in his work. He on the other hand would like to have technology to make him feel the family life when he is away. He would like something that is not as intrusive as a telephone but just gives him a subtle notion.

APPEARANCE

But, it is not only a matter of understanding what technologies the families are willing to drag into their homes and lives, what it should do and how it should work. We need to get the whole picture, which includes the products' appearance and expression. "We surround us or not with all kinds of things. There are certainly practical reasons but we also have more subtle, symbolic reasons for doing so." (Nippert-Eng, 1996)

We need to be able to design the artefacts in such a way that the families will accept to have them in their homes. This will of course include all kinds of aspects like status, exclusiveness, etc. The results could even involve "invisible" design, where the technology is hidden. Since interLiving is a research project, we do not have to consider aspects such as marketing, branding, manufacturing, distribution, disposal, recycling and price. We only have to consider the situation when the artefact is in the home or in the pocket. The focus is on the "needs and desires" that the families express.

Of course, there are lots of technologies like mobile voice phone, SMS, e-mail, etc. that are appreciated by a great amount of people in the "developed" world. These technologies naturally are used by members of the interLiving families as well.

HOME VS. FAMILY

The home and the domestic space is and has been the topic of much research, for example the Equator project in the UK (Equator web) and the Aware Home at Georgia Institute of Technology (Mynatt, 2001). Some, aiming at making them smart, other secure. interLiving instead focuses on families. The most differentiating aspect is that a home is a place, a context, while families involve people. Families sometimes are at home but the members of a family are also visiting friends, at school, at work, playing football, in the hospital, on vacation, etc. And what is even more significant is that they just as often are between different places. Families

Fig. 4. The BongoFax designed during a workshop.

always change in some aspects. Children are born and everybody constantly gets older and older until we die. But other aspects, like kinship, do not change. Your mother will always be your mother.

FAMILY VS. INDIVIDUALS

It is not possible to generalise and please everybody with one artefact. People put personal meaning into artefacts (Csikszentmihalyi, 1991). In Figure 2 and 3 we see cultural probe photos of two kitchens. The different owners have expressed that they have a nice kitchen. The artefacts are presumably chosen and arranged with great care. The pictures show that the styles and characters differ between the kitchens. The owners would probably not agree to switch any single artefact between the kitchens.

How you create meaning with artefacts and the ordering of your belongings is totally individual. The meaning created can be similar between two individuals, but you create it yourself. This is also true concerning communication aspects of technology. Studying the example above, mother in Red family, everyone can see that what she wants is something completely different from what her husband wants.

But there are other examples as well. During a joint family workshop about technology and communication, the oldest son in Blue nuclear household created what he called a BongoFax (Fig. 4). He made a model of a "body fax", a device that could send his whole body somewhere else, like a teleport seen in science fiction movies. It could come in handy when the bathroom is occupied for example. –"Then you just dial your granny's telephone number, turn up at her place, use the bathroom, dial you home number and get back home".

The Blue father's concern during the same workshop was that he never knew where his three sons were. The father explained that the children usually disappear when the whole family is going away from home by car. He wanted to put GPS on each and every one of them to be able to track them.

The BongoFax could be regarded as a design idea that would have to be ruled out since there is no technology available to build teleports. But seen in relation to the more control-oriented device that the rest of the family build, mainly the parents, it can be regarded as an escape device. Being able to "collect" all his children with the help of positioning devices made sense to the father, but not at all to the children. They did not see any problem in this: They were not lost. The BongoFax emphasises that being on their own makes sense to them.

So, the way they want to communicate, or use technology, is not necessarily symmetric. Family communication is not the same as the sum of what the individuals want and need to communicate.

USERS AS INNOVATORS

"Standard" participatory design approaches include having users create design ideas, to have them express problems that need solutions, etc. Often this is done in a rather restricted setting, like a workplace. At work places, there are often helpful boundaries that limit the design space, often a specific task that is in focus.

Another common approach is to start with technology. Specific technology is developed and presented to a group of presumptive users. Users might be able to adapt to use the technology for a while or for long-term use.

We have investigated a different approach in interLiving. To successfully develop communication artefacts that make sense to people within diverse, extended families, we believe that we need to understand the lifeworld of these families. This means getting to know their needs, desires, preferences and expectations. But as stated above, their needs, desires, preferences and expectations will differ among the individuals.

Instead of general descriptions that are reduced and without detail, we focus on actual descriptions of real situations that make sense to the family members. These descriptions should cover the whole context of the situation.

We know from experience that users normally have difficulty in verbalizing blue-sky ideas that are relevant to their situation. We do not expect them to "tell" us what they want. The work is done together, we guide them through the combination of diverse collaborative methods mentioned above and they project their lifeworld through them.

WORKSHOPS

The workshops have at least two objectives: to generate design ideas and to get to know one another. We start the workshop activities by introducing something that frames or focuses the work. This is not done so much verbally as visually, like showing video clips from interviews with the households.

After this introduction, the workshops usually continue with a "use scenario". This is developed with the help of critical incident technique where the participants express something real and recent that has had some meaning to them. It could have been something problematic, a breakdown or it could be something nice that had happened to them. In interLiving this should involve some type of communication with others. All this helps keeping the work relevant to and reflecting their real life, expressing real needs and desires. These scenarios work as foundations for the generation of ideas and low-tech prototyping. It is easy to forget details in the design scenario if it is only presented verbally. Therefore, we emphasize that the results should be shown in action.

The Bongo Fax and the control panels above are examples of design ideas that were preceded by step-by-step design scenarios. They are not only design ideas, but also tell us that communication can be asymmetric.

CULTURAL PROBES

The first thing we did after establishing contact with our families was to give them a kit of Cultural Probes. A recently developed technique for getting information about users is Cultural Probes – maps, postcards, disposable cameras, and other materials "designed to provoke inspirational responses" (Gaver, 1999). We sent them diaries, disposable cameras, etc. that would, when returned back, inform us of their lives and relations. We wanted to get back examples of real communication as well as real context.

One of the probe photos from a couple in Green family, in the thirties, shows a bookshelf with several vases in it. On the back of the photography, the woman has written that she liked the vases and the man that he does not like them. The woman had received them as gifts from her parents and sister. This is another example of an asymmetry.

The diaries revealed that instances of non-communication are as important as communication that takes place. One example is a mother that wanted to speak to her daughter that was going away for several weeks but she decided not to call her until the following day when she would have more time.

INTERVIEWS

We followed up with interviews at the families homes based on the material in the probes. Among the great amount of stories were several about mothers not wanting to be reached all the time, while their children and husbands thought that they had the right to reach them. Very significant was also all discussions about the importance of meeting face to face.

TECHNOLOGY PROBES

To get a better understanding of their technology use, we developed a method that we called technology probes. The concept of technology probe combines the social science goal of collecting data about the use of the technology in a real-world setting, the engineering goal of field-testing the technology and the design goal of inspiring users (and designers) to think of new kinds of technology. For us, technology probes are tools that both help us study how family members communicate and at the same time, motivate them to think about new kinds of communication technologies. (Beaudouin-Lafon, Deliverable 1.2).

A well-designed technology probe is technically very simple and very flexible with respect to possible use. It is open-ended and should inspire new activities by the family members. It is not a prototype or early version of a technology because it is not planned to be developed further. Rather, it is a method to help us determine what kinds of technologies would be interesting to pursue.

The technology probe involves installing a working technology into the families' homes and watching them use it over a period of time. Once placed in the home, it should encourage family members to experiment with it in ways we haven't considered and reflect aspects of how the family members interact with one another.

We have developed three technology probes; the videoProbe, messageProbe and storyTable.

The messageProbe is an application that runs on a computer, but the users should not experience it as such. It is basically a shared writing surface available at two or more distant sites. It is implemented with pressure sensitive displays so that all the interaction is done on the screen with a pen on digital post-it notes. What is drawn on one screen is seen on the other screens instantly. This way it resembled the familiar action of drawing on paper.

When installing the messageProbe in Blue nuclear household, the mother said that it would be convenient if they had this kind of shared surface between their house and the summerhouse in the archipelago during the summer holiday.

The fifteen year-old son didn't want to go to the summer house, and the parents were concerned what he would be up to all by himself at home. The father asked if it was difficult to put a web-cam in their house and connect it with the computer in the summerhouse. He wanted to hide it in the kitchen so he could spy on his son. – "If he is sitting with all his friends around the kitchen table crowded with beer cans and I talk to him on the phone, asking what he is doing and he says 'nothing much', I still know what he is up to", said the father.

While the objectives of the probes are to expand design space, generate more ideas, the prototypes objectives are to narrow that space, to help make design decisions.

PROTOTYPING

Working with low-tech prototypes in the families' homes is very successful. It is easier for them to narrow down functionality to concrete design when it is done in the right place. But we have also done mobile paper prototyping, prototypes they carry with them and make prototype work while they are living their lives. This facilitates them to narrow down functionality to concrete design when they are in the right context for what they are doing.

The inside of the Blue family's front door was suggested as a good place to leave messages on an early probe photo that the family sent us. This photo would be re-discovered a year later and function as one trigger to "The Door Prototype". The idea of "the Door" is investigated through a series of different prototypes. First several low-tech ones like paper pads and Post-it notes that the family has used in their home. The result from these has impact on the software prototypes that the families use later.

CONCLUSION

The fact that we blend researchers with different backgrounds together with users in every part of the developing process, help us in understanding the users lifeworld better. Together users and researchers innovate communication artefacts that make sense to the families. This is done with the systematic use of a combination of diverse collaborative methods and repeated reflections. During these activities we focus on descriptions that cover the whole context of real situations that make sense to the family members.

It is not sufficient to reduce human action into simple concepts like “communication, coordination and collaboration”. This categorisation might give some guidance to initial understanding, but the intentions, feelings, context and values have to be considered and understood as well. But to fully understand the details requires an understanding of the whole. And that in turn requires an understanding of the details. This shift of emphasis between detail and a broader view is very rewarding but also time consuming.

As one example, partly described above, we can look at the concept of asymmetry. It has emerged out of reflections of the data that the families have generated. The concept then is used on other everyday situations to see if it functions as a means for understanding and describing them as well. Finally all the communication artefacts that we are developing support asymmetric aspects of communication.

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We gratefully thank our family design partners for their contributions, as well as all the other researchers involved in interLiving in France and USA, without whom this work could not have been conducted. The project is supported by EU IST FET, through the Disappearing Computer Initiative.

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Educating Multi-disciplinary Design Teams

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Abstract

Designing interactive systems requires diverse expertise, which is why most successful design teams are multi-disciplinary. Unfortunately, managing such teams can be difficult, because team members often do not communicate effectively with each another. When we teach interaction design, we address this problem explicitly, with a two-fold approach: First, we explain the value systems and some of the key assumptions from the component disciplines, including social sciences, engineering and design. Second, we teach hands-on techniques, often with video, that place team members (and users) on an equal footing when expressing design ideas. We want our students to understand and respect the contributions of others outside their discipline and to be able to use design techniques that allow all team members to actively participate, whether observing users, generating new ideas, prototyping systems or evaluating them.

Keywords: Multidisciplinary Design, Science, Engineering, Design

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Introduction

Designing interactive software is complex, requiring an understanding of human beings, software systems and the interaction between the two. Understanding people involves input from at least three social sciences. Psychology explores how the human sensory motor, perceptual and memory systems work, Sociology explores how people interact with each other, and Anthropology explores how people operate in the context of their daily activities. Developing interactive software also requires input from software engineering, including system architecture, programming languages, interaction techniques, as well as distributed computing and the use of a wide variety of hardware input and output devices. Creating innovative and aesthetically-pleasing designs requires input from trained designers, including graphic or interaction design and increasingly architecture and industrial design.

No single discipline provides all the necessary expertise: designing interactive software requires a multi-disciplinary approach. However, forming and managing multi-disciplinary teams has its own problems. Someone trained exclusively in one of the necessary disciplines is likely to interpret the design problem from within the framework of that discipline. This causes problems when people from different disciplines use the same words to mean different things or use different words to mean the same thing. As Djkstra-Erikson et al. [5] point out, "design" itself is a particularly troublesome word. Designers can only effectively communicate what they mean when they talk about the design *of* something: whether it is of the user experience, the screen layout, or the software architecture.

Another problem is that different disciplines place different values on different aspects of design. Scientists are trained to seek explanations of existing phenomena, engineers are trained to provide technical solutions to well-defined problems, and designers are trained to explore a design space and find solutions that "work". When people from these different backgrounds come together, they often run into conflicts due to their lack of a shared definition the problem.

Of course communication problems are not restricted to cross-disciplinary teams. For example, although research scientists share some common characteristics when compared to engineers or designers, when compared to each other, we also see different priorities research methods. An experimental Psychologist who runs laboratory experiments values reliability and precision in the data. An anthropologist who studies people in field settings values context and the validity of the data.

Designers too operate with different priorities. For example, if you ask a book designer, a video producer and a photographer to design the layout of a screen, they will choose different focal points of attention. A book designer is trained to emphasize text organised in a grid and "knows" that a reader will look for the most important information in the upper left-hand corner. A video producer understands the aspect ratio and visual quality of video and "knows" that the center of the screen is the hot spot. A photographer used to the flexible aspect ratio of film and the fine gradations in visual quality will consciously avoid the center and will placement of key items along diagonal across the screen. Of course, any individual designer will deviate from these design principles for any particular design. What is important to understand for us to understand is that these designers are starting from different underlying principles: when they break rules, they are breaking different rules. When these rules are not stated explicitly, other team members are likely to other designers processes and solutions.

Component Interaction Design Disciplines

If we are to teach people to successfully participate in multi-disciplinary design teams, we must go beyond the explicit content of each discipline. Students need to learn about the diverse underlying value systems of relevant disciplines and reflect upon how they interact at a meta level.

Figure 1 shows some of the different disciplines that contribute to effective interactive system design. The three primary contributors derive from the social sciences, computer engineering, and design. From the natural sciences, we commonly find contributions from experimental Psychology (usually Cognitive Psychology, but increasingly Ecological Psychology and Activity Theory), as well as Sociology, Anthropology (particularly Ethnomethodology) and Human Factors or Ergonomics. From these social sciences, we borrow research findings, such as how people perceive information or how human memory works, as well as research techniques, such as how to run controlled experiments or conduct observational studies in the field.

Designers who use research techniques from any of these scientific disciplines must distinguish between their use in a purely scientific context and as a resource to support design. The underlying assumptions surrounding how these techniques are used, and the goals of the research, may differ greatly.

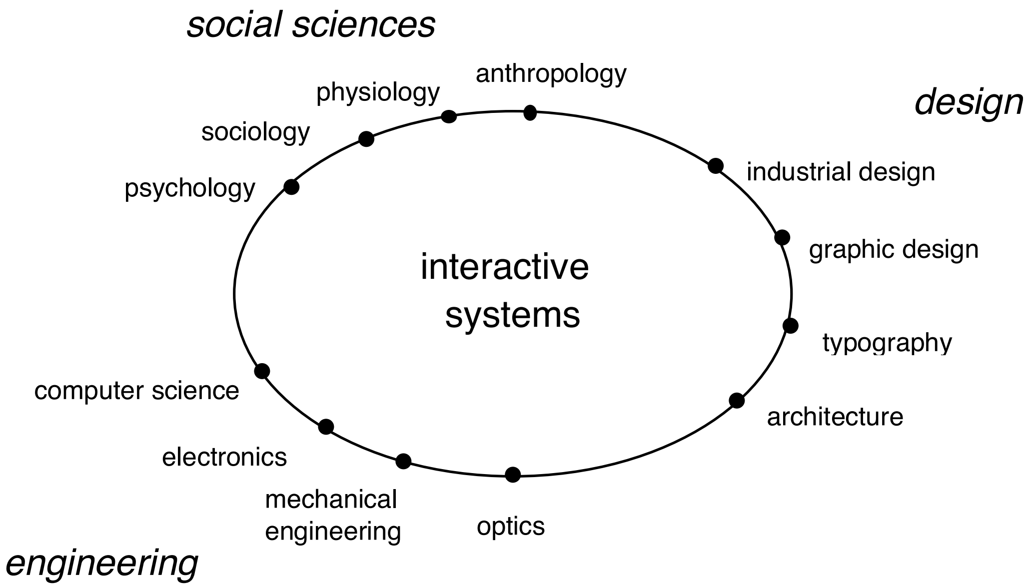

Figure 1: Interaction Design requires input from science, engineering and design disciplines.

For example, a usabilty study is not the same as a Psychology experiment. In experimental Psychology, the goal is to learn about fundamental characteristics of human beings, which exist independently of the experimenter. Controlled experiments are performed to test theories of human behavior, with the idea that they can be replicated by other researchers, who will then challenge or support the theory with further experiments. In contrast, usability studies are designed to evaluate particular software systems. Sometimes, the system is compared to another system, but the studies are rarely fully controlled in the scientific sense. The purpose is not to test theories of human behavior but rather to find problems with the system that was built and to test the adequacy of a particular design solution. Usability studies are rarely performed with the idea that they will be replicated and extended, but usually stand alone. A usability study is considered successful if it offers concrete information about the success of the particular system design for a particular set of users, but need not contribute the our general understanding of human beings.

Similarly, HCI professionals are careful to distinguish between *ethnography* and *ethnomethodology* [2]. The former consists of long-term observational studies of people in different contexts, ranging from anthropologists observing indigenous peoples in the bush to observing white collar professionals at work. Researchers attempt to describe behavior, seeking to identify general characteristics of human behavior as well as specific incidents of unique behavior. One of the roots of the word "ethnography" is "graph", which means "to write". Ethnographers, as scientists, are expected to contribute to a constantly-growing body of research literature, in which they compare and contrast their findings with those of other researchers.

Interactive system designers may profitably borrow observational techniques from ethnography, because they provide useful ways of observing and interpreting behavior in real-world contexts. However, the purpose is quite different. The designer uses ethnomethodology, i.e. methods from ethnography, to contribute understanding that is specific to the development of a particular software system. As with Psychology experiments, the particular techniques may be very similar but the context and underlying assumptions are quite different.

Engineering poses a different set of problems. One concern is that engineers are usually trained to solve problems that have been given to them and are evaluated on the technical validity of their solution, not the relevance of the problem. Yet designing a system by strictly following a set of design requirements does not guarantee a successful product. Human users add complexity and unpredictability to the situation and solutions that appear correct on paper may not be valid in practice. Software engineers are not taught strategies for questioning the design problem, so they often find themselves solving the wrong problems and ultimately failing to meet the needs of their users. Creating formal models of users and simulations of their activities provides a comforting feeling of having considered user's needs, until the software is actually used. Technical expertise is essential to the development of quality interactive software, but that technical expertise must be used to software the "right" problems.

The design disciplines, such as graphic design and architecture, represent the third critical component of interactive system design. Unlike engineers, designers *are* trained to question the 'design brief" and come up with alternative solutions. They have a very hands-on, apprentice-based learning process, in which they create designs for their portfolios, which are critiqued by faculty and fellow students. However, in many design schools, the needs of the user are not reflected in the design brief, or if they are, designers are given few tools to actually determine those needs. Designers must develop their own methods for finding out about users and are not taught strategies for objectively comparing design decisions.

Each discipline offers valuable skills and perspectives; each has the potential to miss important aspects of the design problem. Multi-disciplinary design teams offer a solution, covering the full spectrum of design approaches, taking advantage of the strengths offered by each discipline while mitigating potential blind spots. However such teams pose another problem: participants must be able to communicate effectively with each other. The next section describes some of the issues designers face when attempting to work in a multi-disciplinary design team.

Working in Multi-disciplinary Design Teams

In the previous section, I identified some of the characteristics of the disciplines that provide fundamental contributions to interactive system design. Each have long-standing academic and professional traditions, with different values and specific research or development techniques. When someone trained in one of these "traditional" disciplines begins to work on the design of interactive software, he or she is faced with a problem: how to reconcile the differences between what was learned and how it is applied in the new design context. Most social scientists aren't taught the differences between research studies in a scientific and a software design context: they must discover this on their own. Similarly, engineers often discover that the design requirements are a moving target and they have not been given strategies for successfully developing code in such a dynamic environment. Designers may also be frustrated, since their work is suddenly subject to different kinds of critiques and evaluation than they faced in design school.

As educators, we face the question of how to train people to become successful interaction designers. One strategy might be to try to develop expertise in all of the component disciplines, teaching scientific, engineering and design principles. However, it is unlikely that many individuals will become expert in everything: it is far more likely that individuals will show talent in one area. A gifted artist may be enjoy drawing and design but may find systematic observation of users or programming software to be difficult or uninteresting. Similarly, a trained observer of people may be able to contribute greatly to the understanding of the user's work, but may not be able to program or create elegant interface designs. A talented programmer may find talking to users or brainstorming interface design ideas equally difficult. So, while a few talented people may be able to contribute effectively in all areas, it is far more likely that they will find themselves contributing their expertise as part of a multi-disciplinary design team.

We have a different strategy, which is to continue training people from within their chosen major disciplines, whether scientific, engineering or design, but to increase their understanding and appreciation for the other disciplines. Students are exposed to different value systems and discuss how they may interact with each other.

Although ensuring that each person understands the perspectives of the others is important, it is rarely sufficient. We have found it necessary to create design activities in which all members of the design team, including users, can participate equally. These design techniques are borrowed from the full range of sub-disciplines and we discuss with students the implications of using them in a design, rather than their original, context. We choose techniques that increase communication among participants and we encourage students to develop new techniques that cross disciplinary boundaries. The next section describes some of these techniques, borrowed or inspired from various component disciplines described above.

Hands-on Interactive Design Techniques

Interaction design is an iterative process, as illustrated in figure 2. Students, whether at the University level or professionals in the field, are expected to participate in all of the design activities, throughout the design process. Although the process is presented as circular, it is important to recognise that, once begun, the design team can and should revert to any of the earlier stages as necessary.

We begin by "finding out about users", using techniques drawn from the social sciences and design. We then work on generating a design space and expanding it by creating new ideas. Once we have a suitably rich design space, we begin to select particular design directions and begin prototyping a design. At any point, we may decide that we need additional information about users or new ideas to help make design choices. At various points through the development, we evaluate our the design, beginning with early prototypes and continuing through to the final working system.

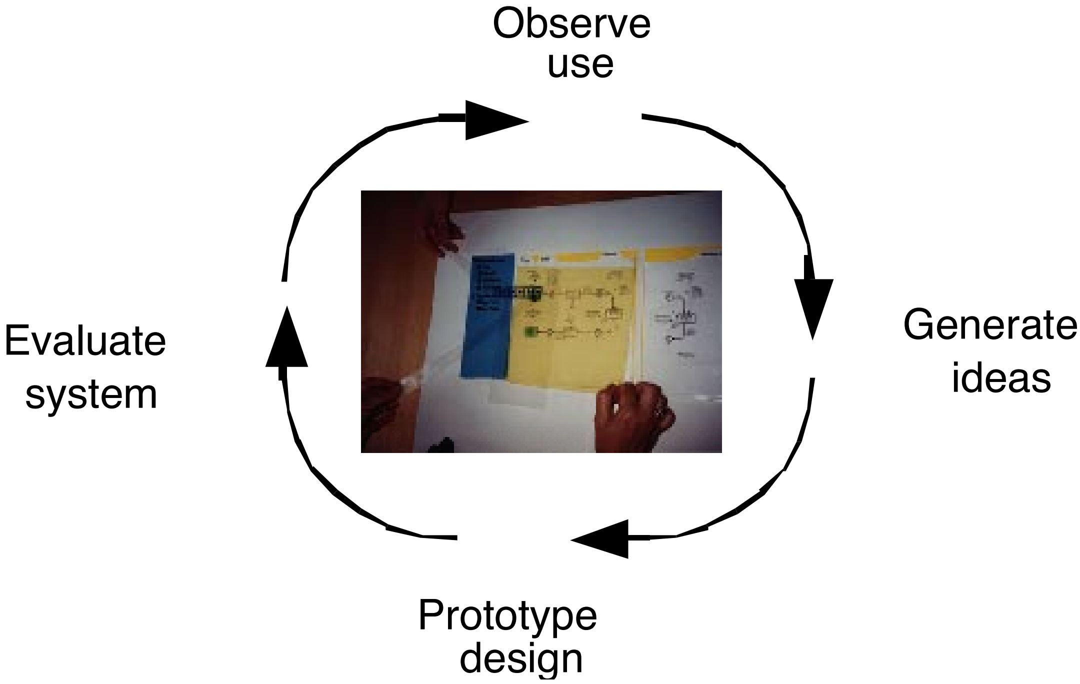

Figure2: The interaction design process is highly iterative and requires techniques for finding out about users, generating new ideas, developing design prototypes and evaluating aspects of the system.

Table 1 summarizes a set of observation and design techniques that we have adapted from various disciplines or have developed explicitly. We believe in the concept of "triangulation" [10, 12], in which we use multiple design methods to help us avoid particular design biases. We use these techniques in our own research and development work, as well as for teaching: these are the techniques that have stood the test of time. They are simple to use, speed rather than hinder the design process, and all serve to increase communication within the design team and among designers, users and various other stakeholders.

(Note: The video-based techniques in table 1 are illustrated in a DVD tutorial by Mackay [13], available through ACM/SIGCHI.)

Ethnography	Cognitive Psychology	Psychology	Participatory Design	Marketing
Human Factors	Human Factors	Psychology	Participatory Design	Human Factors
Sociology	Activity Theory	Design/Arts	Computer science	Psychology
Psychology	Sociology	Participatory Design	Human Factors	Psychology
Design/Arts	Cognitive Psychology	Design/Arts	Computer science	Design/Arts

Table 1: Design techniques derive from a variety of disciplines.
Items with bold outlines are described in further detail in the text.

Finding out about users

The first phase of the development process involves finding out about the needs and desires of the future users of the system being designed. Sometimes a system already exists, sometimes not. In any case, it is important to find out about the context in which the system will be use in order to begin to define the design problem.

From the social sciences, we use observation and interview techniques [15]. Video is a useful tool, although it should be used judiciously: I tell my students to only videotape what they are willing to later watch. With respect to interviews, we have borrowed a technique introduced by Flanagan [7] from the human factors community, called "critical incident technique". This and other related techniques are based on an important observation about people: if you ask people specific questions they will give you specific answers. You can then generalize or ask them to generalize for you. If you instead begin with general questions (such as "How do you use your email?") you will receive general answers that provide very little that is useful for designing a future system. So, when interviewing people, the key is to find specific objects, events or times that people can describe and elaborate on. This specific information that can then be woven into design scenarios.

From design we have the notion of cultural probes [6] from Gaver and his colleagues. Here, the emphasis is not on collecting data but rather on involving future users and helping them generate inspiration for design. Cultural probes are specific objects, such as a map to create or a camera to take photographs, that users use to comment on their existing world and to generate ideas about future possibilities.

We have recently been experimenting with a new method that we call technology probes[8] which attempt to incorporate both scientific data collection and design inspiration. For example, for our interLiving Disappearing Computer project, which studies technologies for distributed families, we have created simple, limited-functionality prototypes that we have placed in family members' homes. These probes provide direct, private links between households and enable sharing of video images or hand-written messages. Technology probes designed to both collect information, informing us about the communication patterns within the families, and to provoke new ideas, inspiring both the family members and us as designers to create new technologies to meet needs we had not previously observed.

Once we collect information about users, we need to analyse or interpret it, not for its own sake but to inform design. It is important to preserve the context of the user's activities: we do not try to abstract out a set of abstract tasks, but rather seek to present each user's activities in context. The most effective strategy we have found is to develop scenarios [3, 9], which combine the experiences, both typical and unusual, of different real users. We begin by creating a "day-in-the-life" story, and then break the story up into an illustrated storyboard. Sometimes, we create video scenarios, either with video clips from actual observations or re-enactments of events we've observed. These scenarios provide an effective communication tool for all members of the design team, and give us a way to discuss what we've learned with the users [16], who can give us feedback and enrich the scenarios.

Creating a design space

The second phase of the development process involves the creation of a design space [1]. Here, the goal is to generate new ideas and to increase the set of design possibilities. Brainstorming [4] is the most common technique: The classic procedure involves a small number of people who are given a specific topic and a limited period of time.

Everyone participates in generating ideas, all of which are captured on a blackboard or flip chart. Another variation asks everyone write down ideas individually and then share them with the group. A moderator ensures that all comments are constructive, that the time is spent generating ideas, not evaluating them, and that the session finishes on time. The time limit is very important: brainstorming is very intense and, if done well, will leave everyone energized and excited by the ideas, not tired and bored. Brainstorming usually has two phases: the first for generating ideas and the second for reflecting upon them.

We have discovered [14] that the quality of the ideas change according to the way they are created. Verbally shouting out ideas, as recommended in classic brainstorming, is effective for rapidly generating large quantities of ideas, but the ideas themselves are poorly developed and often vague. People quickly lose the context in which the ideas were created and flipcharts from month-old brainstorming sessions are mostly useless. Drawing ideas rather than saying them requires more reflection and other participants often have an easier time understanding them. We push this further, by asking participants to show their ideas, via paper or more elaborate prototypes. This forces both idea-generators and other participates to concentrate on what it will be like for users to interact with the idea in question. Such ideas become more concrete and we find that they are more likely to inspire further ideas.

For us, the most effective technique is video brainstorming [1] in which participants demonstrate their ideas in front of a video camera, using rapid paper or other prototypes. Not only does this produce a more valuable record of each idea, which can be reviewed and expanded upon later, but it is very effective for encouraging participants to think concretely about how users will actually interact with the proposed idea. Video brainstorming also forces active participation from everyone. Each idea has an author, who directs other members of the group to play the role of the user or the system to illustrate the interaction. Video brainstormed ideas allow participants to "sketch" interaction ideas and share them, even if they are not expert programmers or graphic artists. We have handed video brainstormed ideas to programmers, who can rapidly prototype code and allow everyone to explore the ideas further. We also find this an excellent technique for working with users, who can contribute directly to the design process without any particular technical skills. Once the team is used to it, video brainstorming is only slightly more time-intensive than other forms of brainstorming, but we find it much more useful, since the resulting video record of design ideas continues to serve as a source of inspiration throughout the design process.

Prototyping a design

The third phase of involves making choices: deciding to pursue some directions and omit others [1]. Unlike the idea generation phase, which values quantity not quality of ideas, the purpose of this phase is to explicitly narrow the range of possibilities and choose a particular path. The goal is to explore a more restricted design space, considering the details of each design decision and creating a grounded design that is both innovative and still makes sense to real users in real-world contexts.

We use a variety of prototyping techniques, ranging from very rapid, paper prototypes to intermediate software prototypes, from "Wizard of Oz" [11] techniques to working systems. When we develop video prototypes, we revise the use scenarios that we created in the first phase of the design process and explore how a new design would be used in that context. We develop the system design and the scenario together, changing each to meet the needs of the other. Once we have several scenarios that illustrate the use of the new design, we create storyboards and prototyping materials, and illustrate the design ideas with a video prototype.

This process is very effective for giving all participants in the design team, especially users, a voice in the process. Everyone can see what the design implications are for particular design decisions, and everyone can suggest and show alternatives. If people disagree, they can return to techniques from the earlier design phases to gather more information or generate alternative design ideas.

Evaluating a system

The final phase involves evaluating the design: is it a successful solution? Are there specific problems that need to be fixed? Do the users like it? We run various kinds of studies to answer such questions. Sometimes, it is important to run controlled experiments. However, usually, it is more important to simply find a number of users and watch them use the new system. We usually ask pairs of users to sit together and comment on the system out loud, which makes it easier for them to express their opinions to us. Normally, we ask them to try a set of tasks or run through several scenarios, and simply watch how well they are able to use the system. In addition to videotaping them, we use the computer to log their interaction with the software, so we can obtain quantitative data about errors and efficiency of different user actions.

Another useful strategy is a design walkthrough, based on Yourdan's [17] work with structured walkthroughs. A "walkthrough" is a peer group review of a product: people at roughly the same level in the organization meet to systematically review and discuss a segment of software. One can review code, architecture or any aspect of the software, including video prototypes. The rules are simple, but important: Groups should be small (3-7 people), members of the group should be at the same level, the presenter should prepare in advance, everyone must be on time and the review should be limited to at most one hour. The goal of the walkthrough is to identify as many problems as possible, not to discuss solutions. Criticisms should be as positive as possible and should be restricted to the design at hand. Walkthroughs are similar in format to brainstorming sessions, but opposite in their goals: walkthroughs seek to find problems, brainstorming sessions seek to maximize the number of ideas.

Conclusion

This paper has described our strategy for teaching interaction design. We begin with the recognition that design is multi-disciplinary and that few individuals can be expert in all of the necessary fields. We teach our students how to think about the design perspectives of their colleagues: what are the most important contributions of each design field and what are the potential sources of misunderstanding? We also teach specific, hands-on design techniques that draw from all of the component disciplines of human-computer interaction. The techniques described in this paper are explicitly intended to equalize the level of the participants, enabling everyone to actively contribute, including users. Using these strategies not only improves communication among members of the design team (and users!) but also improves the efficiency and effectiveness of the design process. People can explore a wider range of ideas, and select promising design solutions earlier, with greater relevance to users, using these design techniques. Of course, team members with specific skills in specific domains, such as interviewing, programming or graphic design, will not only be able to contribute their expertise, but will also benefit from knowing that others will recognize the value of their contributions. Finally, these techniques are fun; participants of multi-disciplinary design teams should enjoy designing interactive systems!

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Agile Design of Interactive Systems

ABSTRACT

This paper analyses experience from a design and development project in the user oriented and cooperative design tradition, where multiple competences, i.e. ethnographic, industrial design and software development specialists, work closely together.

In the project families in their home settings participate in cooperative design of communication devices with the specialists, who all participate together in sessions with the users in field studies and design and development sessions.

It is clear that this close cooperation between competences makes it much easier to get the user experience influencing the whole development process than in traditional system design and development processes, where ethnographers hand over to industrial designers who hand over to software developers.

It is suggested to name this practice ("culture") of working agile design, inspired by the agile software development culture, developed from extreme programming, where close cooperation, e.g. in "pair programming" and frequent user involvement is recommended.

An analysis is given of similarities and differences between agile design and agile software development and where these experiences can fruitfully influence each other.

Categories and Subject Descriptors
[D.2.2 Design Tools and Techniques]:

Evolutionary prototyping, Object-oriented design methods, User interfaces

General Terms
Performance, Design, Reliability, Experimentation,

Keywords
Agile design, agile software development, multidisciplinarity, ethnography, industrial design, computer science, software development, shared knowledge, cooperative design

1. INTRODUCTION

Ethnographer (E): "*I was at a conference in Helsinki on ICT with my industrial designer (D) work partner. His first goal at every site he visits, is to find some sort of Internet connection, and then read and send email. At this particular conference, we sat in the audience of a panel discussion. It was quite interesting from what I remember, but not so interesting that we did not read work e-mail at the same time. We had email from our computer science colleague (C), that we read on D's Macintosh.*

We all work on a project together where one of the ideas is to make a time constrained ink to draw with on distributed shared surfaces. C was at home in Stockholm working on the first prototype. He sent a fairly long e-mail telling us about the implementation of all the features that should be in the prototype, about invisible ink, the icons that should represent different things like pens and time aspects and so on. In one sentence he then told us that for a moment his own pen on the screen disappeared. Soon he realised that he had made the pen with the same disappearing ink that the pen was supposed to draw.

We just laughed, quietly. It is very typical of C:s way of programming, and then, in all the confusion, he gets a new idea. The disappearing pen gave a hint to us that you should not be able to make your own tools with the same qualities as the ink, or else all your tools would disappear."

Computer scientist / programmer, C: "*The most rapid thing to do was to use the same ink for the pen. And it did not take long before I realised that the pen disappeared along with its ink. Using constrained ink for tools would be an interesting and attractive approach, from a developer's point of view, to make all the tools from lines drawn with the same kind of ink that they themselves manipulate.*"

This anecdotic account of how the members of a multidisciplinary team experience each other shows that differences do not necessarily lead to misunderstandings but rather that different aspects on the design and development can lead to better joint understanding. We will in the following analyse experience from this kind of close cooperation of researchers / developers from design, social and technical science disciplines. We regard this as an important and valuable design practice which we call agile design in analogy with the agile programming practice, [10], that has emerged from "extreme" and object-oriented programming, [3].

The practice also follows the traditions of the Scandinavian model of Industrial Design, where involvement of users and other competences is a natural component.

About this way of working in interaction design we have only found a few references, e.g. [14] that treats cooperation with between designers and a human science conversation analyst in a similar way, and [1], which brings agile software development thinking into a qualified interaction design audience, Doors of perception.

2. BACKGROUND – interLiving PROJECT

The experience reported and analysed mainly comes from the interLiving project, "Designing Interactive Intergenerational Interfaces for Living Together", [7], It is coordinated by CID (Centre for User Oriented IT-Design) at KTH (Royal Institute of Technology) in Stockholm, Sweden. Partners are INRIA (Institut Nationale de Recherche en Informatique et Automatique) in Paris and LRI (Laboratoire de Recherche en Informatique, Université de Paris-Sud). The interLiving project was funded for three years 2001-2003 by the EU IST FET research initiative "The Disappearing Computer".

2.1. Participants – families and researchers

We work together with three families in Sweden and three in France, each family consisting of several households. This paper mainly reports on experience from the work done in Sweden. Similar work is done in Paris by our two partner research labs there.

The project builds on the Scandinavian cooperative design tradition, [4], and is multidisciplinary with researchers from computer science, ethnography and industrial design. The participants represent different ways to conduct research, design and technology development work. Also, in the EU FET (Future Emerging Technologies) research planning there is a strong awareness of the importance and value in bringing in end users as design and development partners [12].

In January 2001 we put an advertisement in Metro, a free tabloid, distributed in all public transport, searching for "Families to participate in research project about communication and new technology".

The criteria were that the family should consist of three generations and live not more than two hours from central Stockholm. We received 40 replies and chose three of those.

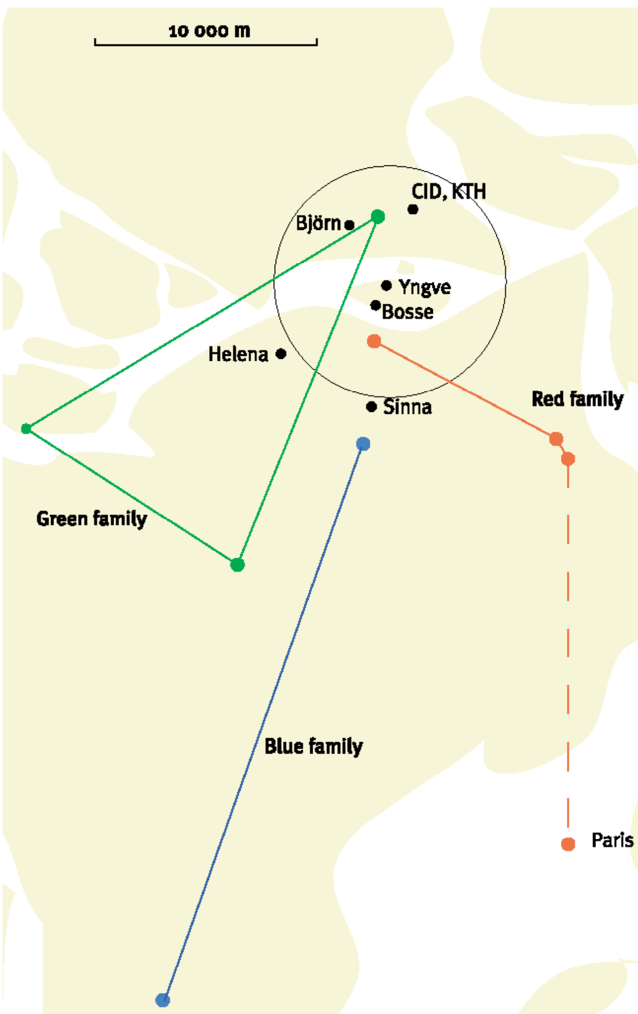

Figure 1. Geographical locations of participants in Greater Stockholm

The three participating families in Sweden consist of eight households spread out in the city, in the archipelago and in the countryside, see figure 1. They live both in apartments and houses. We call the three families Red, Blue and Green. The youngest participant, when we started, was nine months and the oldest one seventy-two. To work with real families means that we co-design with individuals of different age, different skills, different desires and needs. A three-year project meant co-design with the same people for three years, with changes over time in age, skills, desires and needs.

2.2. Methods

The interLiving project had two related objectives: To develop novel and appreciated communication artefacts and to improve design methods.

But how do you do co-operative technology development with families? Depending on the users different age, skills, needs and desires we knew that we had to approach the individuals in different ways. You cannot make a four year old do the same things as a fourteen year old or a forty-four year old. By engaging the family members in several different methods and activities, we get to hear and see many different aspects of their life.

To understand the needs of families in their every day life, to develop innovative artefacts that support these needs and to understand the impact communication technologies can have, we use combinations of diverse collaborative methods like workshops, cultural probes [5], technology probes [2] and [6], interviews, prototypes, etc., as triangulation, [8]. These methods are described in [13].

Mixing and trying out methods is one way of approaching our group of users as individuals for design work. It is also a way of understanding how these methods can be improved. We want to investigate which ingredients from each method that are important during the development.

With co-operative design we also mean that the multidisciplinary research group, consisting of an industrial designer, a computer scientist and an ethnographer, should work closely together continuously during the whole project. There should be no need for "handing over information" between ethnographers, industrial designers and computer scientists. At least two from the research team should be present at every activity with the households.

Another important issue here is that we all, users and researchers, have experience of family life. We all belong to a family. Therefore, we are not striving for all experience related design decisions necessarily to be made by the users.

2.3. Working in people's homes

We visit the households to observe and to do interviews, install technology probes and to do paper-and-pen based and technology prototyping. Some visits were just to install technology, like setting up an ADSL connection and thereafter the technology probes and prototypes. For some households it took us more than two years before this was technically possible. All these activities take time, sometimes almost ridiculously long time. The good side of this is that it gives us more insight and other stories of the families' lives.

When the day for broadband installation eventually came for the Blue nuclear household, we drove to their house in the outskirts of Stockholm. The installation involved two grown up family members, one teenager, a computer scientist, an industrial designer, new network cards in the family's own computer, several phone calls to "support", etc. The scheduled one evening installation became two days. No one still knows why the installation did not work the first day.

But one afternoon one of the sons happened to connect a telephone to an outlet that his parents didn't know of and then the ADSL connection started to work. And after that the ADSL works even without the extra phone connected.

These kinds of time and effort consuming activities, is the reality for all of us, researchers as well as family members, when working with technology and the home.

2.4. Asymmetry

Also, many of our partners express a need to be left alone without someone being able to phone or access them all the time. The mother in Red family was very clear on that point. – "It is not everybody's right to be able to contact me all the time!" She has four children, the youngest was nine when the project started and the oldest was 21. She works full time and is family life head coordinator since her husband is traveling a lot in his work. He on the other hand would like to have technology to make him feel the family life when he is away. He would like something that is not as intrusive as a telephone but just gives him a subtle notion.

2.5. Appearance

Understanding what technologies the families are willing to drag into their homes and lives, what it should do and how it should work. We need to get the whole picture, which includes the products' appearance and expression. "We surround us or not with all kinds of things. There are certainly practical reasons but we also have more subtle, symbolic reasons for doing so", [11].

We need to be able to design the artefacts in such a way that the families will accept to have them in their homes. This will of course include all kinds of aspects like status, exclusiveness, etc. The results could even involve "invisible" design, where the technology is hidden.

Since interLiving is a research project, we do not have to consider aspects such as marketing, branding, manufacturing, distribution, disposal, recycling and price. We only have to consider the situation when the artefact is in the home or in the pocket. The focus is on the "needs and desires" that the families express. Of course, there are lots of technologies like mobile voice phone, SMS, e-mail, etc. that are appreciated by a great amount of people in the "developed" world. These technologies are of course used by members of the interLiving families as well.

2.6 InkPad prototype

The InkPad is a digital message surface for drawing/writing and sharing notes in real time at a distance, e.g. between households. The ink is supplied by pens handled with interaction device, e.g. mouse, pen or finger, and can have temporal properties such as disappearing after a while, recurring every Monday morning etc. This makes the InkPad useful for messages, reminders and real-time communication both within households and between households. Our intention is to enable communication of both important facts and more informal chatting in a way both youngsters, adults, and elder members of the family, computer literate or not, could find useful and "fun".

3. EXPERIENCE

Here we give accounts from the three participants, Ethnographer (E), Industrial Designer (D) and Computer Scientist (C) on how the work has been performed, and, most important, how the complementing competences and different aspects work together in concrete situations in the design and development work with the interLiving families.

3.1. Technical probe installation at Red grandparents' house

Ethnographer (E): "*It's a lovely spring afternoon with the sun shining in a low angel. It's one of those days when you have to wrinkle your whole face to be able to see anything.*

Monica, grandmother, opens the door before we have even stopped the car. She wants to greet us and to tell us to park the car on the plane in front of the garage. We start to unload the car. It's me, D and C. The car is full of stuff for the installation at Monica's place and at the nuclear family afterwards. We are joking about moving into her house with all the boxes and bags. After some helloes and how-are-yous we start carrying all the boxes upstairs to their bedroom. The bedroom is the place where they keep their computer and therefore where they do their bills. Their home is very clean and tidy. The beds are made very properly. There are no personal items laying around, more than for the books their bedside tables. There is a clothes hanger where there are some clothes very neatly folded and hung on.

Figure 2. Probe installation team

The room gets crowded with Monica, D, C and me and all the cardboard boxes. D and C start to unpack and Monica ant I try to keep out of the way. I ask her if it's ok to film some of the installation of the technical probe and the ADSL connection. She thinks it's ok. We start to make jokes about all the wires that always goes with technology. I tell Monica that that is one reason why I want to film the whole thing. In one sequence of the film there are two men sitting with their legs crossed and a manual that looks like a map in their hands. At one time

D starts to laugh and turn it around and starts reading on the back of it. I think they had forgot to do what was in the first step.

Monica and Leif bought a new computer about a year ago. –"It's strange they have to look like this!" , she says. The computer is a grey big box, placed on a desk with a desk mat and room for writing etc. D and C asks if she knows if there is a network card in the computer. Monica doesn't know and refers to Maria (daughter in law) who was the one installing the computer. If they want to know anything in particular about the computer they should ask her.

Monica goes downstairs to put the kettle on. The installation was supposed to take about an hour. That was what we had told her. And then we were going to the nuclear household. The installation took longer than that. There was a used device that was hard to reset. But before we knew that we thought that we had come across some neighbours wireless network, because there was a login name, Hedenberg, and a password. D and C asked Monica if she new anyone with the name of Hedenberg. She said she didn't, but she thought that she knew that one of the neighbours had put up a network. So on Monicas' initiative she and I went outdoors to read on mailboxes or ask the neighbours about any Hedenberg. But we didn't find any."

Lesson: The thorough documentation by E makes C and D confident to work with their task without side thoughts on recording the experience. The ethnographer makes interesting observations of roles and the whole situation around the technology.

3.2. The Ink idea surfaces, at the lab

Industrial Designer (D): "*The idea of time constrained ink simply surfaced or evolved during one of our many "just sit in the sofa and discuss nothing special" meetings about a year and a half into the project. There had been a lot of activity and some of that had direct influence in the idea. We had the probePhoto of the blue nuclear households inside of their front door, and then the workshop where the "back of the door" design scenario was generated. At the same workshop there was also prototypes of "active reminders", i.e. notes that grew bigger to attract more attention as the event got closer in time. But probably most important was the evaluation workshops with the Green families concerning their messageProbe use. They thought that it had been so fun.*

We sat all three, me the computer scientist / software developer (C) and the ethnographer (E) in our room at the lab and I mentioned an idea that a student just had shown: A marker with disappearing ink. The scenario she used was when you were to meet somebody at a café and the person was late and you did not want to wait any longer. Then you could take the marker and write on the café table "See you at the museum" or something. Then the late person could catch up if (s)he arrived within say a half an hour. After that the ink would just vanish.

The people using the messageProbe had lots of notes asking the other people "Are you there?" Does anybody want to draw now?" These messages were only interesting for the authors for a few minutes. Then they would themselves go away from the messageProbe. (This was an interesting result from not having a delete function on it.)

C said that it would not be so complicated to implement that. Messages and drawings could be made by hand and some of them could vanish after a defined time.

I was surprised and delighted. This was really fun. I did not think that this would be possible. We had been working with the "Back of the Door" concept for several months but we had only considered using "printed text" (ASCII) i.e. input from mail clients, keyboard, etc.

C said after a short while:

- We could also have appearing ink. This is typical for a remark from him. He is so trained in some sort of structural thinking that often results in clever remarks like this.

Remembering one of the paper prototypes done earlier, where all reoccurring events had been ordered on one side, someone said:

- This means that we could have ink that showed up every Monday or other weekday representing activities that somebody needed to be reminded of.

We had a longer discussion of pros and cons concerning the properties being held by the pen or by the ink."

Computer Scientist (C): "*I remember the context very clearly sitting around the coffee table discussing, but I can't remember the particular date.*

I really get excited of the idea of disappearing ink and after we had discussed the basics I could see a lot of areas and applications where the ink certainly would simplify the process of finding a good "metaphor" but also the implementation as such. Maybe we had even stumbled on a new paradigm! Why hadn't anyone thought of it before? It is so natural and obvious!

My brain was going at top speed. How to implement? Which areas are suitable? How should it be presented to the end-user? What about generally constrained inks? What about distributed applications? Etc, etc."

Lesson: An inspiring idea generation session where ideas bounce around in the multidisciplinary team, adding aspects and producing a joint result where contributions are collective.

3.3. Installation at Blue young family home

Industrial designer (D): "*First evening I and C were here trying to install ADSL. Everything went wrong. We tried to find the telephone outlet and found something completely insane. Behind it in the wall there were 240 Volt cables and loads of other wires. It was impossible to understand what cable was connected to which thing. Their house had, a week before been struck by lightning. It was possible that modem and network cards in the computer had broken and even a cordless telephone seemed to have broken. But no one did really know. So, during the last week Eva, mother, had tried to get rid of all extra telephone outlets that did not work and Thomas, father, had asked all their neighbours where they have their first telephone outlet so that perhaps he could understand where he had theirs. All the neighbours have it in the entrance hall. Unfortunately, the previous owner of the house seemed to be a real "handy-man", or at least he thought he was, so their first telephone outlet is on the top* *floor.*

Seven-year-old Emil, who was lying on the bed in the same room as where I and C tried to install, said:

- Don't you think that this is booring?

Within a couple of minutes he had fallen asleep, which made us realize that we ought to call it a day and give up.

An observation is that it often seems easier for me than for D to explain to the family members what the technical difficulties are. I am an amateur, D knows all details which sometimes confuse."

Ethnographer (E): "*C, D and E went to their house for the second time to make the broadband connection work with a modem, their own computer, a router and also install a Cube (Mac) and a touch sensitive Wacom screen to interact with the software on.*

We enter their home with all the boxes with the computer stuff in and nests of wires. Thomas and Eva are at home. They always tend to be a bit expectant, pursue a wait-and-see attitude. Not ignorant but just a bit awaiting. They are always open and really want to help us. Thomas wants things to work, so it is never a problem with wires and things we suggest to put into their home. He always wants to find solutions to where to put things, where to hide wires and cords. He did the same thing this day. When C is taking the Cube and the screen out of the boxes to put in their kitchen on the side-counter, Thomas is asking things about how long the wires can be and how many electric connections does the "thing" need. He is looking behind the microwave oven where there is an electric double-plug and let his hands follow the top of the cupboards hanging over the counter, to feel if it is possible to put the wires on top of them.

Eva is even more of a spectator. She also attends more to other things in the house. When the phone rings, she answers and when Emil is coming home, she meets him in the hallway to hear how everything is and what he is up to. She doesn't bother to stand beside all of us when C is installing. She comes and goes, moves around the house. Then once in a while she stands beside, looking and gives input that could be relevant for the installation.

We are all in the kitchen and C puts the Wacom screen and the Mac Cube in place. In the meantime, Thomas wants to tell us little interesting "family miscommunication story" (his own words) from last Wednesday That involves a series of phone calls between his sons that he should have gotten to know about but did no, like so many other times.

Then we go upstairs. They have their computer in a study. C and D start to discuss what could be wrong with the connection. In different orders, they turn the router off and then on to hopefully understand what could be wrong. Then they do the same thing with the modem. D brings out his Mac as well to see if he could get connected. C is looking in DOS on the Blue family computer to see if it was connected and what number it had. Both C and D talk a lot about different IP-numbers and numbers from the router to the connected computers. Thomas had bought a new "something"-card and put it in the computer if it perhaps was that that was wrong the first time. That might also have effected why it didn't work this time.

After almost an hour of work, I was just standing beside and watching, C, who was the one crawling around on the floor, checking wires, connections and buttons, changed the router to another one, and then did the whole thing work. The first time of installation, they had brought a brand new router and both D and C thought that would help them in not getting any trouble. The second router was a used one. Why that one worked and not the brand new one no one knows. In the car to the Blue family I was joking about the fact that it is not very often that you actually want brand new things to be broken, but that was the case here. We thought it might help us in understanding why it didn't work. Unfortunately, it didn't help us much anyway. I just suppose that C, and probably D, are still thinking about what could they have done wrong or what could be wrong with the installation.

When everything worked upstairs, we went down in the kitchen again to actually show the software. Eva and Thomas said they hadn't used it themselves. In their family it is perhaps just grandpa Calle and the two oldest sons that were with us at the review meeting in Gothenburg when we showed it there, so they have used it. Again, both Thomas and Eva are waiting for someone of us to show how it works. They are not afraid of it, they are just the wait-and-see-state.

...

We pack our stuff and bring all the boxes with us out in the hall. There, just before we leave, Thomas asks us if we knew who first got the access with the broad band? It was 12 year old son Charlie, (if I remember correctly). "He just plugged in the telephone upstairs!" We all laughed. Then D and C had even more stuff to talk about in the car back home. They didn't come to any conclusion on what was wrong or what might have happened.

My comments to this is that it is amazing that you need to so many educated people just to get access to broad band. And when you eventually get it, you still don't know how to do it, or rather, what went wrong in the first place."

Computer Scientist (C): "*It is very enjoying to read what really happened in retro-perspective. As a software developer and installer/hardware installer I don't have time or the opportunity to take notes. But reading this in E's vivid language I see a lot of requirements the family members have, without expressing them explicitly themselves. This stimulates me and makes me think of thousands of little applications, widgets, and tools we could develop and provide them with. But sadly at the moment we don't have resources to implement them. Nevertheless since E has written the episodes down we have kept the background information for later continuation."*

Lessons: The ethnographer really contributes with an interesting account on the lack of reliability of telephone and computer connections, of trail-and-error work, of roles played by the members of the design team and by the family members. The industrial designer as "amateur" often has easier than the software and technology specialist to explain technological problems to the family users.

3.4. Prototyping work at the Blue family household

Figure 3. Prototype discussion in family kitchen

Industrial Designer (D): "*One of my interests from the start is to check how well they understand how to interact with the "interface". Can they manage to draw, move a pen, change colour, etc. I think the stuff still looks rather crappy so I won't even mention appearance, character, etc. It's really a problem that I myself can't work directly on the software, but have to hand off ideas to C, who implements these but see them as some of many, many things that ha has on his list.*

The other topic is the most important one. That is to discuss/investigate with the people in the family how they would want to use it. We have done this before but now we need ideas on how to set the time constraints on the ink. As I see it we need restrictions. I do not think that they would want all the accuracy of an office calendar. I guess days are enough for future drawings. I remember when Eva said that when they have an updated calendar on the fridge, she looks at the current day before she goes to work. So I guess that this is how they would like the InkPad to work as well, displaying stuff happening the current day."

Computer Scientist (C): "*I really want to focus on the interface first. Particularly since I know how hard the development of non-trivial distributed applications are. Further I like to work in the "agile way" of focusing on the "satisfaction of the customer" and more generally starting out from the behaviour of the application. I believe, among other things, that if we very rapidly construct a graphical interface we would smooth the interaction with the families and more likely get better feedback and suggestions from them. But on the other hand I am aware of the importance to make an application that could be shared among several households, in particular to respond to requirements from our discussions with the Green family. This is really hard; trying to implement an infrastructure good enough, make some suggestions for behaviour and tools, but still trying to avoid steering the families in the hope of getting out something new that we couldn't or at least wouldn't come up with ourselves without this kind of co-operative design.*

I also find the looks of the stuff quite crappy. From my point of view in this early stage of the development I don't want to, or have time to, spend hours to make all the icons and everything visually attractive. First I want the application as such work properly. There really is too much to do for one single programmer and I wish that we could find a way to more directly incorporate D's very nice artefacts into the application. Of course I could use D's GIF-pictures directly, but then I get problems with scaling, animation and in particular rotation, which is required for some of the tools and ideas we wanted to test.

I really want to focus on the interface and behaviour of the application and try hard to avoid thinking on all the implementation details while we are discussing the evolvement of it. However it is really assuring to be in a team of three with one designer with a feeling for the aesthetics and similar things, a human factors oriented person looking at the families as such and really notating the requirements, needs and proposals they make, and me (the computer guy) having to program the thing. But I also find it very stimulating that we don't have clear cuts between us and freely step into each other's fields with suggestions, proposals, and lengthy discussions of all the various parts involved in the development. In this way I am forced to look at the application with other eyes than the computer scientists. Further, since we have become such a tight group, I am not afraid of suggesting the craziest things. I know the other understand that it is a kind of brainstorming and me myself could rely on them "aiding me" if any of the things I personally propose lead to bad interface design or contradicting what the families really need. I hope E and DI have the same feeling and not are afraid to suggest things even if they feel unsure of the feasibility to implement them at all.

Still I have to consider what is possible and feasible, but in this stage we are building a prototype and want it to be a prototype of what we really believe would be a attractive application and not just "a feasible one". And all the time things like "the most important user stories first", "the simplest thing that could possible work", "always having a working system", and "refactor to make the code clean, simple, and expressive" talks to me. But still I like the creative phase where we discuss the wear abuts and behaviour of the application as freely as possible and don't want to restrict it with boring what-is-possible-to-implement details. And I believe that we still need a little bit more to trigger good ideas from our families."

Lessons: There are clear differences in attitude towards the interface between industrial designer and software developer and clear frustrations for the software developer that his tasks need much more effort to fulfill what he wants to achieve.

3.5. Different ways of expression

Ethnographer (E): "*We all talk about the same things, but in different ways. One afternoon I overheard a conversation between D and C. They talked about some of the difficulties we had had with the prototypes. I can understand that they understand each other but they use different language. C is talking about which subroutines to call and how to do that and D is talking about the same thing but in terms of plug-ins. This time I wasn't part of the conversation so I didn't need to have an opinion at all. Usually I understand fairly well how the things work too, but I am more interested in that it works.*"

Industrial Designer (D): *That was exactly what we were discussing as well. I wanted us to use the erasing possibility the Wacom pens afford in some applications. And that would have let us take away the trash can from the display.*

If you turn the pen "upside-down" and rub with the back it works as an eraser on the back of a pencil in for example Photoshop. C then said that he had not discovered any difference in the information from the Wacom depending on which side was touching the display. I then remembered that in an early version of Photoshop you had to install a "plug-in" to make this feature work. C then called that a subroutine. What I saw as a "black-facilitating-box" was something more transparent to him."

Lesson: With good cooperation climate differences in ways of expression can be overcome.

3.5. "The trees and the wood"

Industrial Designer (D): "*I try to keep conscious of both the whole and the part all the time. The emphasis shifts but never is one excluded.*

The consequences of the fact that design is both an instrumental process and an activity that always takes place in social context require us to reflect on designed artefacts in at least two ways. One involves structural properties: analysing the physical and technical properties and behaviour of the artefacts we design. The other involves functional properties: the purpose and role that the artefacts we design take on in social use,

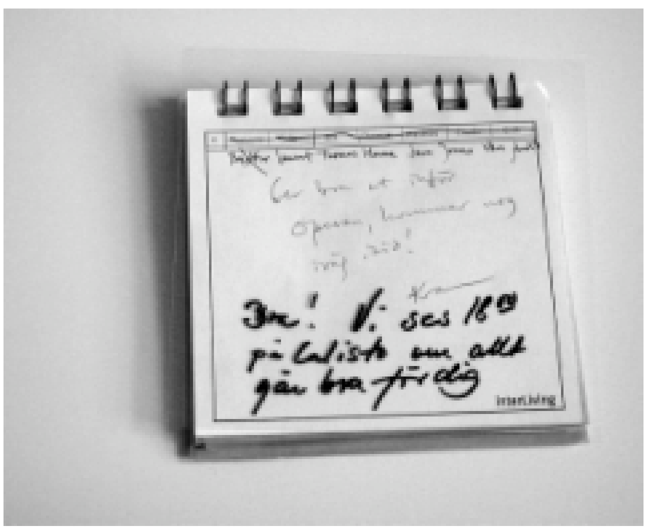

Figure 4. InkPad paper mock-up

An example is when Eva (Blue family mother) foresees that there will be lots of notes on top of each other, all invisible at the moment, but they might show up at the same time. So we discuss for a while the possibility to look into the future, to change the local time and date of the InkPad. Another idea is the equivalent of heating paper where you have drawn on with lemon ink. That way all notes would be visible at once. Eva seems to like the idea of scanning through the future best. Then she could check "next week", i.e. the drawings and notes that would appear during next week would represent events that are planned.

Here I try to realise both how to simplify and minimize the interaction and also make the results as useful as possible. Actually not only for this isolated use but for other uses as well although the emphasis is mostly for the use Eva is discussing."

Computer Scientist (C): "*Yes, a better "interface to time" is really precious, if not imperative, to prove the concept. But at the same time I see how hard it could be to implement, especially since there is not really time to refactor the application in the way I want now. But I am not completely satisfied to patch the code and just refactor as much as I could find time for now. I really wished I could change the overall structure of the application into the one I now think would satisfy our present needs best. I didn't have this structure in mind in the first iterations since at that time I mainly focused on the basic functionality of the ink. But now since the application really has to be turned into a distributed one some solutions would have gained a lot from a re-structuring.*

And how would this time-line be developed in the best way? I have some ideas, D has some, E has some, and we also have some in common. But at the moment it is hard to make the families come up with ideas, at least not concrete enough to just go about and implement."

4. AGILE DESIGN AND AGILE SOFTWARE DEVELOPMENT

In [10], pp. 6-8, the agile software development is formulated as a manifesto with 12 basic principles. Here we take up some of these and discuss similarities and differences with agile design with cooperating design teams, as described in this paper. Some are here formulated slightly simpler than in [10].

• *Welcome changing requirements, even late in the development*

• *Deliver working software frequently*

• *Business people and developers must work together daily throughout the project*

• *Build projects around motivated individuals*

• *The most efficient method of conveying information is face-to-face meetings*

• *Working software is the primary measure of success*

• *Agile processes promote sustainable development*

• *Continuous attention to technical excellence*

• *Simplicity – the art of maximizing amount of work not done*

• *Best architectures from self-organizing teams*

From XP, extreme programming, [12] and [2], we take some of 14 more precise directions on concrete practices according the principles above. Under each we first give the XP interpretation and then how it adapts to agile design (AD).

• Customer Team Member

XP: Customers and developers work very closely together, aware of each other's problems.

AD: In our agile cooperative design practice users and developers work very closely together, respecting and being aware of each other's problems, needs and desires.

• User Stories

XP: Ongoing discussions about requirements resulting from short joint scenario discussions.

AD: In our agile design stories like the ones related above are very important for getting a joint understanding of use situations. Rather than the deliberately very short stories recommended in XP we want full-fledged stories. The stories in this case are actual events that all three persons have heard and experienced together. This means that the stories do not have to be re-told but just referred to. The stories are both stories that the users have told the team but also of the stories that all the visits and workshops have generated

• Short Cycles

XP: Deliver new release every second weak.

AD: While developing the team make frequent visits to the different households that participate in interLiving. This is true both while conducting the low-tech paper prototyping (figure 4) and during the software prototyping. One of the reasons for this is to take advantage of the increased focus and interest that the family members have during the period.

• Pair Programming

XP: This is probably the most famous and controversial XP advice. The pair works together in all program writing and testing, taking turns at the keyboard with the other looking for mistakes and improvements.

AD: This has a direct correspondence in our agile design practice of always having at least two competences from the design team present in all activities.

• Sustainable Pace

XP: This is in principle an advice to avoid all over time, except very near a release, in order to keep the team conserving its energy and alertness.

AD: In the agile design, as in most human activities that need alertness, this is an obvious advice not always followed. In cooperation with users it is also important to keep a reasonable pace in order not to wear out the users.

• Open Workspace

XP: An atelier like open room with many chairs around computers for conversations and walls covered with charts from planning and brainstorming activities.

AD: This is obviously at least as important for an multidisciplinary agile design team in order to keep the discussion from different aspects on-going. Our industrial designer and ethnographer work together all the time that type of workspace, while the computer scientist only visits now and then, sometimes with very innovative results as described above. More continuous placement in the same open space would probably result in more innovative ideas with all three aspects taken into account.

• Simple Design

XP: Start with the simplest thing that could possibly work. Resist adding features and infrastructure before it is really needed. Do not tolerate code duplication.

AD: We at all times try to make the application as simple as possible, partly for aesthetic reasons but also as a means not to confine our users with pre-fabricated solutions. Our intention is to facilitate the human-to-human relations. The artefact itself, hardware and software, should cause as little resistance as possible to the users, in order to make use meaningful. Hopefully this approach maximises the users' abilities to contribute with non-foreseen solutions and in the process as such.

• Refactoring

XP: Adding features after feature and dealing with bug after bug often leads to a degraded program structure. Refactoring is a practise of tiny transformations that improve the structure without changing the behaviour.

AD: In the agile design this mainly corresponds to efforts to make the control and information from devices as simple as possible by removing unnecessary features.

• Metaphor

XP: The metaphor is the big picture that ties the system together.

AD: As a means of enhancing the communication among us and with all members of all families we strived for a good metaphor. This attempt leads us to the constrained ink metaphor. This particular concept would certainly not have taken an as important role in the development without this joint effort to find a metaphor that all of the various expert categories and families would have found both natural and useful.

5. CONCLUSIONS

In this paper we articulate the value of close cooperation and sharing of experience by all members with different expertise in a design team through accounts of a number of concrete design sessions with and without users.

Thus, such close working together has shown so positive results that it is strongly recommended. For many interaction design situations it should be fruitful and efficient to work in multidisciplinary teams in all activities, sharing experience in field studies, in design sessions, in program development.

As told in the experience accounts below there are many situations where the team members see aspects that complement each other and also specific roles played by the members that can alleviate for the others.

One example is the ethnographer's skill in writing notes about the experience and observations, which gives the other members freedom not to worry about forgetting details. More important it gives a holistic view and understanding of the full context of use of technology.

Another example is the computer scientists' responsibility for the hardware and software installations, with some assistance by the industrial designer, vividly accounted for.

A third example is the "amateur" industrial designer's sometimes better ability to make users understand technological problems that the specialist system developer's.

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interLiving:
a multi-disciplinary cooperative design approach

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ABSTRACT
In this position paper we describe how experience from a ICT research project, interLiving, can influence HCI education. The project also raises interesting aspects on the role of design research. The interLiving project is an example of a successfully conducted cooperative design process and could therefore have impact on both HCI and design educations. These impacts could influence the view on multi-disciplinary work, participatory design and what methods to use.

This is a research case study that can be used to show how fruitful close collaboration between people with different background can be. It also shows that it is equally rewarding with close collaboration with users. We believe that this experience can have great impact on HCI and industrial design education.

Author Keywords
Cooperative design, user-centered design, education, methodology, design research, design process, multi-disciplinary, ICT, HCI, computer science, industrial design, ethnography, cultural probes, prototype, workshop.

ACM Classification Keywords
H5.2. Evaluation/methodology, Prototyping, User-centered design.

INTRODUCTION
One of the most common models of a design process is the waterfall model where different activities are performed in sequence, i.e. first studies, then design, programming and finally testing. The research project interLiving used a different approach where instead people with different background worked together throughout the whole project.

The role of the user is also a debated issue. Should the user be involved near the end and *test* the application? Should the developers be regarded as *experts* and users only be treated as customers? The interLiving project had users involved throughout the whole project.

These and other experiences from the interLiving project provides HCI education with interesting aspects of how to conduct a design process. Some of these aspects are:

- How to cooperate with people from different backgrounds
- Cooperative design
- The range of methods available

INTERLIVING
interLiving, 'Designing Interactive, Intergenerational Interfaces for Living Together', was carried out during 2001-2003 and was funded by the EU Future and Emerging Technologies, initiative the Disappearing Computer [1]. The research was conducted both in Stockholm, Sweden and in Paris, France. The researchers had a background many different disciplines, ethnography, psychology, computer science, industrial design, interaction design, graphic design, cultural studies and ergonomics [7].

One of the objectives of interLiving was to develop artifacts that use information and communication technology to facilitate intergenerational communication within families.

There was no specific problem, solution or technology in mind from the beginning. How could we find out what to do? How could we get hold of the design ideas that would be reasonable to develop?

Another of our objectives was to try out, modify and describe different methods for co-designing with persons in private settings, like homes. We wanted to develop methods that let the family members participate and influence the design throughout the whole process.

We used the concept of *family* to describe close relations spread over generations. The three Swedish families we work with were distributed in three households each. The participants' ages varied between one and 75 years. We worked with the same 30 people throughout the three years. The researchers in Paris also worked with three families.

We will now first describe some of the strategies and methods we used. After that we discuss the impact this can have on HCI and design education.

Co-operation between different disciplines

interLiving was conducted in the Scandinavian design tradition and was multidisciplinary with researchers from computer science, ethnography, industrial design and psychology. The participants represented different ways to conduct research, design and technology development work.

We decided that we should work closely together continuously during the whole project. There should be no *handing over information* between ethnographers and computer scientists for example. At least two from the research team should be present at every activity where the users were involved.

Cooperation with users

We strongly believe that cooperative design is a successful approach. In interLiving this meant expanding this field from mainly dealing with work-related matters into families. We know that it is difficult to be innovative by just talking about what technology you want in the future. But on the other hand people can be very innovative when they are given the right tools and circumstances.

Several different methods

There are of course many different ways to conduct a design process and no approach can guarantee success. Little is actually known about where, why and when the ideas that lead to successful solutions appear.

Our approach was to use several different methods in trying to get to know the family members' different needs and desires [11]. This approach is called triangulation [6]. We calculated that what does not show in one method would be revealed in another. And strong aspects would have impact on the findings from the use of several different methods. We decided to use cultural probes [2], workshops, observations and interviews. Of course prototyping was included as well. The workshops themselves included the use of several different methods, like critical incident technique, low-tech prototyping and scenarios. We emphasized that the results should be shown in action.

After some time we also developed Technology Probes which are complementing Cultural Probes [1] [4]. These are scaled down, feature-slimmed applications that are on their way to become disappearing computers in the sense that 'we [are] freed to use them without thinking and so to focus beyond them on new goals' [10]. The technology probes gave us interesting information about the families' use of technology.

Prototyping

Contrary to the common opinion of design the focus during the work is not the artifact but the future situation of use. Krippendorff writes: 'Design concerns itself with the meanings artifacts can acquire by their users.'[5] The future use of the eventual artifact was in focus during most of the work. We worked directly with prototypes in the families' homes to get as rich understanding as possible of what the different family members experienced as meaningful. We installed low-tech prototypes that were *used* for some weeks. Following that we had workshops in the homes reflecting on the result. These activities naturally gave us a lot of specific information about the use and context.

Later on in the process we installed software and hardware prototypes in the households. These were also evaluated in several different ways and thereby revealing important aspects of the peoples needs and desires.

'The practitioner allows himself to experience surprise, puzzlement, or confusion in a situation which he finds uncertain or unique. He reflects on the phenomenon before him, and on the prior understandings which have been implicit in his behavior. He carries out an experiment which serves to generate both a new understanding of the phenomenon and a change in the situation.' [9]

Process

Since understanding of the different aspects was a necessary ingredient we needed to work with researchers from several different academic professions together in all events. All activities, like interviews and probe photos, were discussed and analyzed this way. The prototyping work done in the families' homes was conducted by an ethnographer, an industrial designer and a computer scientist together. We worked closely together and minimized the usual sequential way where one person hands over the results to the people in charge of the 'next step'. The result of this was a greater depth of the investigated aspects and also in a better, and mutual, understanding. We worked together even during other phases, planning, workshops, etc. This gave us all the "same" experience about the three diverse families. We constructed a common ground to work together from in the development.

There were several sources of inspiration for this, partly experience from our own practice and horror stories about the lack of results from the 'waterfall' or 'toss it over the wall' way of working. We were also inspired by Henrik Gedenryd who stressed that 'design cannot be separated into stages.' [3]

IMPACT ON HCI EDUCATION

We believe that it is very important for HCI students to be aware of the advantages of working together with other disciplines as well as with users. There are several ways of doing this and it is important to realize what the strengths of the different approaches are.

Design, an intentionally, holistic driven approach

The participants represented different ways to conduct research, design and technology development work. One of the key aspects of design is that it is driven by intentions. Nelson and Stolterman write "… intention is not the target, nor the purpose, nor an end state, but is principally the *process of giving direction*."[8] These intentions are guided by the experienced and imagined desires that the (future) users have. They are also guided by the possibilities and constraints that you recognize at that moment. We all have different perspectives and therefore recognize space, time and actions slightly differently. This is why it is fruitful and important to work together and not in sequence.

Design focus on that-which-is-desired and in prescribing that, focus both on the whole context and on the details. The designer needs to be informed about relevant issues by the HCI specialists and social scientists. The social scientists and HCI specialists will in their turn be guided by the intentions that the designer provides. Done well the whole team will together construct *shared intentions*. These shared intentions will have another key design aspect namely a holistic approach.

IMPACT ON HCI RESEARCH

Although the approach used in the interLiving project proved to be successful there are naturally many issues that need to be researched further. Some of these involve development of methods and strategies. Other issues are trying to understand concepts like intentions, meaning, desires etc. better.

CONCLUSION

The fact that interLiving blended researchers with different backgrounds together with users in every part of the development process helped the researchers in understanding the users lifeworld better. This shared understanding resulted in shared intentions. Together users and researchers innovated communication artifacts that made sense to the users. This was done with the systematic use of a combination of diverse collaborative methods and repeated reflections. During these activities the focus was on descriptions that cover the whole context of real situations that made sense to the family members.

These insights may contribute to the development of HCI (and design) education in several ways. By learning this, hopefully through projects with students from other disciplines, the HCI students will have easier to decide:

- how and when to involve users
- when and where to collaborate with designers (and people from other disciplines)
- what they need to provide the designers with regarding constraints, context, framing, etc.
- what result or feedback to expect from collaborating with designers

We believe that the purpose of teaching design to HCI students should have the objective of facilitating their future collaboration with designers (and people from other disciplines).

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Reverse Archaeology: Designing artefacts for life in the connected home.

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Abstract

The design process we describe in this paper, is a speculation on the way families can live with new types of material objects, made for inter household communication. Whilst archaeology looks at physical objects to speculate on how people lived in the past, we have designed physical objects and persuaded people live with them to discover what kinds of culture can develop in the future. If we had such objects, then what kind of ways of living would follow? Our design work: a series of appliances for physical communication; is used to discuss and understand the way that individuals might live with always on communication appliances that connect remote homes together.

Project Background

The working process and prototypes described here were developed in the context of the InterLiving project (IST, Disappearing Computer), a European research project centred on developing new methodologies for designing technologies for distributed families. Since little is known about users requirements for communication appliances in the home, the InterLiving project has been primarily focused on getting families involved in the design process so that they can influence us right from the beginning. The design brief was to define the problems in this area as well as to suggest directions for future research.

Although based in a computer science department, we were working in a multidisciplinary team of social scientists, computer scientists, software engineers, design practitioners and interaction designers. By giving developing prototypes and testing them in real contexts we can gather more realistic information about how users respond to our designs and what ways of living that they support. We have attempted to have a dialogue with our users over the course of 18 months, presenting them with prototypes and sketches to try out at home. Since we have situated our research in the context of real people's homes, we needed to develop clear design goals and a strategy whereby the objects fit naturally into the home environment.

Design Goals

Design as we understand it in the commercial sense is restricted by the market, we know what is an object is, what it does, we have its list of functions and design is there to fit the object into a targeted market niche, to compete with similar products. Design research, on the other hand, is not restricted to market constraints, occupying a speculative space, its products are free to evolve and explore new types of human relationships to their objects. We are researching to find the 'right' values and their corresponding ethics and functionality. Whilst a requirements engineer may be looking for the keys needs and desires for families and the designers is then asked to respond to these needs, our objective was to understand what could be meant by family values and how might media products create (rather than respond) these values.

The design space

Our design constraints can be summarised as follows:

- Make one simple function
- Make it as neutral and minimal.
- Make new forms whilst 'referencing' existing objects.
- Make it stable and if not then make it easy to reboot

One simple function came from the notion of Technology Probes(1) which are designed as simple objects that are able to log patterns of use by users. Technology Probes are supposed to have one function but be open to interpretation so that they can be used in multiple and unexpected ways.

Complimentary to the one simple function rule, we developed the one simple aesthetic rule. Since we were working with real families, it came quickly apparent that individual members had different lifestyles and tastes, so the designs had to be 'neutral' enough to fit in each of these homes. It would have been difficult to install the technologies as they come out of the box, since the mess of cables and industrial packaging would make it unacceptable for some of our families to live with. Furthermore, we wanted to steer away from peoples' preconceptions about how technologies could be used and interfaced with, so it was important that our users do not perceive the technology underneath. However, since the objects needed a form we were necessarily entering the problematic space of subjective values, taste and aesthetics. However, these aesthetics have a profound affect on the way that the object is used.

Design practice is a process and activity whereby the designer shapes the character, identity and culture surrounding a physical object. Since the Italian New Wave of avantgarde design in the 1970s, the object has emancipated itself beyond the pure function it serves. The design of an interior artefact can be an embodiment of its surrounding cultural context, a style of a particular movement or even a self-referential aesthetic that points to already existing designs, such as a retro design. The products of design have a certain form and material, they can be touched, moved, kicked or stroked. The form and the material also act as a catalyst for people to make the object "feel home" in the home, to truly integrate it. This means the object finds a place among the rest of the people and the artefacts living already there even before its arrival. This process of truly integrating an object it is very important since only then it is possible to use it effectively. If an object doesn't fit into the natural sphere of the home, it is edgy, an outsider and remains unused, broken or destroyed. From a design research perspective, it is not enough for the object to act simply as a container to package technology; rather the object can become an embodiment of the media experience that it engenders.

Our aim was to develop an aesthetic that was a neutral as possible and to develop original the physical forms for each of our objects. The physical objects we designed, refer to existing objects but are also unique, in that they have a new form to suit their specific function. They are actually "new" types of objects, for new types of usage. i.e. not simply an augmented object but to create a 'thing' that has its own identity. What is more, we wanted the designs to trigger the families to think of new ways of using the device, so the form were designed to be abstract enough to continue to evolve, so that they are open to interpretation and undefined usages, leaving space for the object to be defined by the imagination of our users. To achieve this end, we would sometimes start by augmenting an existing object, to begin the process; installing prototypes at regular intervals in family homes and developing the objects further to create an original form for the object. This process, as we shall describe project by project, was a dialogue between the original idea, and the constraints of the technological functions, the family members and the material form of the technologies being used.

Central to this desire to create "new" topology of objects for always on inter-connected homes, is the appreciation of the 'trans-formative' properties of digital media. Whilst design is traditionally concerned with forming materials we also look at transforming properties of media from one form and location, to another. This idea allows us to create something truly new; that cannot be made with pure analogue form.

A family of Objects

VideoProbe

Since the last deliverable the VideoProbe has been installed in 4 more family homes. The response from the families was collected in the form of a logbook...where they were placed: doorway, sofa, dining table. Functions?

MirrorSpace

MirrorSpace is a video-space that allows distant people to make eye contact and uses physical proximity to support both ambient awareness and communication.

As the name suggests, MirrorSpace relies on the mirror metaphor. Live video stream it captured and sent from mirror to mirror, the resulting images are superimposed onto each other at both locations, so that people see their own reflection combined with the reflection of the remote person. Two distant people looking into a mirror can merge their portraits into one.

Each MirrorSpace is equipped with a camera. As we aim to support intimate forms of communication between family members, it was important for us that people could actually look into each other's eyes. To achieve this, we placed a small image sensor and lens in the middle of the screen. This setup supports participants to feel close to remote people, sustaining a longer communication.

In addition to the camera and the display, MirrorSpace also include a proximity sensor that measures the distance to the closest object or person in front of it. Distance is used as a variable to alter the image that is displayed. Blurring distant objects and people allows people to perceive the movement or passing of the other without revealing their identity, offering a simple way of initiating or avoiding an encounter. Participants can express their level of engagement simply by moving closer or further away. It is a physical interface, invisible, which works with the way that people already behave. Adds a new dimension to communication, introducing the physical aspects of communication.

Prototyping MirrorSpace

The first MirrorSpace prototype was shown at UbiComp in October 2002. This prototype consisted of one LCD, screen covered in mirrored film, a proximity sensor and a USB web camera, which filmed activity of passers by in real-time. This live video image was set at a 50% transparency and over-layed onto a pre-recorded film taken by videoProbe in one of the InterLiving family members home.

For the next prototype, we initially planned to build 5 mirrorSpace kits that members of the lab could run on their laptop to test the system across 5 remote places. However, after testing the software on one laptop we realised that this test was too far removed from a real home setting to be of any use to us. The use of the web cam placed on top of the laptop meant that people would never be able to look at each other in the eyes and more importantly, the activity of working on a laptop is very different to the activities that take place in the home. At home, people move through space as they engage in a range of different work and leisure activities. However, in front of a laptop people move very little, so the whole sense of the project –to use physical distance as an interface to video communication - would have become obsolete.

Given the complexity of real-time video communication, we had to imagine other ways of testing the prototype in settings that have similarities to the family living room but were not remote. Our next prototype consisted of two fully working and networked mirrors that were exhibited in an exhibition open to the general public. [3]. Both mirrors were installed on adjacent walls of a 4m2 white cube. People passing this cube would see their silhouette reflected back at them in one of the mirrors and as they approached they could see themselves in both mirrors. If they were in as group, they would start to play with each other through the mirrors.

The design of this prototype was centred on the functionality of the installation: the placement of the camera, getting the software stable and the technical challenges of making the set up transportable and secure. Our initial intention to cover the LCD screen with a semi-translucent mirror foil was reluctantly abandoned, since it blocked off the light coming from the LCD screen, making it difficult to see the image.

For the next public showing of this work [4], we developed the aesthetic language of the mirrors. Unsatisfied with the technological lab aesthetic of the last prototype, we made three small but fundamental changes to the physical design. This is important as it changes the way that the prototype is received, read and understood by the participant. A real mirror is already perceived as a surface for mediating communication - with its own rules and protocols. As an example, making eye contact with a stranger through a mirror is usually considered less intrusive than direct eye contact. Since the mirror is already associated to this idea of reaching out to other people and other spaces, it acts as an ideal enabling metaphor for establishing a new communication experience. It is therefore important that the object makes reference to the idea of “mirrorness” in its physical form.

We realised that it would be possible to set the mirrors to a portrait format rather then landscape. This simple rotation of 90 degrees (since both LCD and camera were now hardwired together into one box) had a huge impact on the perception of the object by the user. Since the electronic object no longer refers to a computer screen and is therefore freed from this association, and ready to take any other new meaning. Our second alteration was to embed the boxes into a false wall, so that they become a window or a surface (depending on the function) rather than a physical object (or obstacle). Thirdly, we designed a mirrored frame, which both reflects and reveals fragments of the person and their captured image. This frame serves many functions: it hides the technology, it makes a visual association to household frames and mirrors, but it also functions on a metaphysical level, guiding the user through a sequence of spaces. It creates a visual and conceptual transition between physical space, mediated space, and a shared telematic space.

For this public showing we put each mirror on either side of the wall, so that they were in separate (if not remote) locations. Clearly it was less obvious for people to see what happens straight away, but is closer to the proposed situation in a family living room. During this exhibition, we invited the families for a workshop and presented them with MirrorSpace. The advantage of showing them the work in the exhibition setting was that we were able to integrate the mirrors it into the architecture so they appeared to be part of the wall itself. This would not have been possible if we had installed it in their homes. Furthermore, the low bandwidth between each household meant that we were not convinced that the installation would run for any reasonable length of time between two remote locations.

The user response was gathered from both our test families who were invited to the exhibition and also the general public [5]. We found it surprising that most people do the same thing; they pull funny faces at themselves or each other - like the way children do when they see themselves in the mirror and discover themselves as separate entities. One might blame this on the technical limits of our installation (i.e. the absence of audio), but it may also be that people are simply not used to using an intimate shared video space and therefore the social protocols have not yet been developed. Since the setting was public, users can experience surprise or even be disturbed to find a stranger very close. More confident users started to dance with each other, blew kisses to each other, generally had fun interacting with each other and family members were delighted to overlay their faces to compare family resemblances. The female mothers were particularly appreciated of the simple way of protecting privacy, which remaining in contact with relatives.

Mimo

Mimo allows multiple people both locally or geographically separated, to record and mix video with a tangible interface.

Prototyping Mimo

Mimo was conceived to explore the ways that an appliance such as MirrorSpace could be used within a network of family members and across time. Whilst MirrorSpace leaves the possibility of meeting to chance and depends upon physical proximity to create thresholds of engagement, in a network of distant relatives, this situation may not always be desirable. People may not want to meet or they may need to leave messages for someone particular that can be picked up later in the day. We wanted to enable people to actively decide with whom they wanted to connect to and when, so we decided to look at ways to develop a tangible interface for making and breaking networks. Move from informal interaction to coordinated communication within a larger network [7]

During a family workshop [5] we presented our first prototype of what was to become Mimo. It consisted of a table disguising an RFid Tag reader, some cards containing RFid tags, a camera and a projection screen. The cards were programmed to trigger the following functions: Play, Record and Containers. The Container card acts as the key to the video. The initial scenario that we gave to the family members was that they could store secret or public messages for each other onto objects throughout their home. Each Container could be re-recorded at any given time and would record a layer over the first video layer. Up to 10 video layers are possible, so overtime the card erases the last video layer as it records the top layer. This proved to be a lot of fun for the younger family members, who quickly found ways to play with the system.

Having explored the intersection of time with layers of video, we then built a new programme to enable the dynamic making and breaking of networks within a large group of people. We chose to test this during a computer science research conference [4], since there would be lots of people, who presumably might want to network or de-network with each other.

Each card was labled on each side: Me, MyFriends. The ME card would record whilst the MYFriends card would play the video I have recorded. If I wish to share a video space with somebody, we both put down our MYFriends card onto the table. We have now formed a new network. We both share the video-space and will see each other in the same video-space when we place the ME side of our cards onto the table. I can break out of this network by forming another network with somebody else by simply placing two MYFriends cards down onto the table. People generally took a long time to understand this, although younger people seemed to understand more quickly. There may have been some confusion with the naming of the card and in hindsight it may have been better to call the cards ME and NETWORK.

The next generation of the Mimo was inspired by a visit to one family.

RFID tags, modifications for tangible interfaces

As part of this research, we performed lots of experiments with Rfid tags, looking at different ways they could be designed for more complex interactions, beyond simply on/off. The possible interaction techniques that we discovered, but did not realise in a higher resolution can be summarised as follows: Sliding, Rotating, Switching, Scratching and Double sided.

TokiTok

A low bandwidth audio channel between two locations, that reacts to vibration.

This device was developed as a low bandwidth probe, to see how families would use always on, single byte audio channel. TokiTok provides a two way abstracted audio link between two homes. We use the word abstracted because the sound itself is not actually sent to each location, but audio vibration data is transferred over the internet and sonified in both locations. This transformation was designed to protect the privacy of users. If it senses a vibration it will monitor the signal and eventually send it to its remote twin. The remote TokiTok will then emit a series of sounds based on the initial vibration.

We wanted to find out how people might use such a device, if they could create a grammar to communicate messages to each other. We imagined it could be eventually integrated into an appliance such as mirrorSpace to draw attention to someone in a remote location.

Prototyping TokiTok

When we first started working on an audio device, we assembled a quick prototype called the audiobuggy. We adapted a readymade radio controlled car to carry a FM band radio receiver and speakers. We then hooked up a 1kW FM radio transmitter to a microphone. These two devices enabled people to carry their voice remotely throughout the home. We wanted to experiment with this device between remote homes so that people could make audio walks through the homes of their remote family. However, it was proving quite complex to develop within the bandwidth restraints we had, so we decided to strip the concept down to the most minimal amount of information necessary to communicate through an always-on audio connection. We realised that the simplest way of negotiating a communication between people that already exists, is the knock.

People knock onto each others doors to ask for entry, they drum in the jungle to warn or to communicate news, hammer on the radiator in a house, or take a broom and knock on the ceiling if the music of the neighbour is to loud. Short audio signals are used throughout communication to grab peoples attention: People shout at each other, for example “oi”, or use beep the horn when driving a car. Even our computers speak with us when we make mistakes or for example when the machine wants to communicate that something has been done with or without success. The short audio signal always comes into place when there is urgency or a transition from one state to another. Within inter-human relationships, it is used when people want to negotiate a communication, send a warning or express an appreciation. In particular the knock is in that sense a very civilised gesture, since it acts as a protocol before confronting somebody directly without warning. For this reason, we think the knock is fundamental to human-to-human communication and should be developed in its own right as well as a function that can be applied to other devices such as mirrorSpace. We could imagine that it would be comfortable for people to send a knock first to find out about the willingness of other people to engage into a more direct communication experience.

The first TokiTok was designed as a simple rectangular form, which could be placed on any surface within the home: on a table, the floor, hi-fi speakers, the piano etc. This first box contains the sensor, the microprocessor and the circuit. If the box senses a vibration then it will lights up. This gives the user the assurance that this otherwise passive device is on and working. The device measures the intervals of silence and the force of the vibration. When this signal is sent from the device to the URL, the device makes an echo sound. This signal lets the user know what how their knock was translated by the device and that the signal has been sent to the remote location. The remote TokiTok connects to the URL every 4 seconds and if there is a new message it will play it. The sound will be identical to the echo sound.

The translation of the vibration into sound is an interpretation and depends upon the taste of the individual user. Since the family we were working with were musicians, we will ask them to design these sounds for us. The sound consists of 2 background sounds (one for each TokiTok) and a series of 16 different short sounds that are played according to the force of the knock being translated.

Learning from our design experiments

We discovered that designing for the domestic environment is a minefield of aesthetic, social and ethical constraints. As set out in the abstract, the aim of these experiments is to draw conclusions about what topology of communication objects will support a culture whereby families can live ‘together’ across distance. We can summarize our findings into three areas: the system structure, the physical and digital design relationship and the human phenomena that the objects are inspired by.

Mirror-me effect

During the process of developing these prototypes we noticed an emerging phenomena that we call ‘mirror-me effect’ which became a guideline: it is the ability to see or hear a representation of the self. This can be observed in the way that users in mirrorSpace and Mimo see their own reflection in the object at the same time as the remote person and the ability to hear your own knock as well as remote knocks in Tokitok.

The mirror-me effect is necessary for various reasons. Firstly it means that people know instantly and intuitively that the camera is recording or that the device is on. Secondly, it gives people a sense of how they are seen or heard by the other, so they are able to respond to their self-image as well as the image of the other. This means that people have much more control over the way they appear and sound to others. They can respond to their own image and play with the way that they are seen. In a way, it is similar to the way the telephone works, we can always hear our telephone voice whilst we speak and this enables us to feel that we are in the same communication space as the other. It is a way to engage people in the communication space and feel inside it.

In TokiTok the vibration that is captured and sent to the server will emit the sound locally first at the time that the information is sent. This functions in similar way. It allows people to know that TokiTok is on, that the signal has successfully been sent to its destination and allows to people to hear how their signal will be received at the other end. The data of both locations are both equally available in both locations and it is possible to hear the sound from two locations at one time. Likewise, VideoProbe integrates the images from the two locations without distinguishing whose home they belonged to.

We felt this was important principal when communicating over distance since it creates a seamless integration of two locations, a media space, which is neither here nor there but occupying a space in between, joining both locations. This principal is very different from current applications for video conferencing, from high tech corporate versions or cheap webcam sharewares aimed at the home market, whereby the two locations are represented as distinct and separate, often occupying separate 'windows' making it impossible to look oneself and the other at the same time.

Property of Things

[The aesthetic language: this is where we tell the story about creating something abstract that is open to interpretation]

To migrate from the computer screen interface towards ubiquitous/pervasive computing in the home environments, we have used the principle of incorporating secondary function into our designs, so that the interface becomes part of everyday life in the home. For example, the screen can be seen to act as a mirror, Mimo is a shelf or videoProbe can be a picture frame, thus serving recognised roles as well as less obvious technological functions.

From a design perspective this implies that there is a relationship between the physical and the programmable, dynamic media and the precise nature of this relationship is crucial to the experience had by the owner of the object. In MirrorSpace, the reflective frame around the hardware functions in guiding people through a series of transitions: from the real mirror of the frame, to the computer generated mirror of the screen, to the shared video space between two locations. The frame serves to makes these borders more fluid, so people can shift from one space to another.

Both technological and physical form, are used as material to help people build a relationship with these media appliance objects. We developed an aesthetic strategy whereby design builds relationships between people and their objects. Between objects and other objects.

Since we are speculating about the existence of new types of appliances, and these appliances need their own forms, it is not enough simply to augment an existing object. the ability to reference existing objects that people already understand.

Everyday Phenomena

Throughout the project we were searching to find ways to transfer everyday phenomena into the digital domain. By phenomena we mean occurrences that are in some way perceptible by the senses, but also such things that retain a certain sense of pleasure. We focused on very simple family pleasures: the photo album, eye contact, physical distance, rhythms and role-play as sources of inspiration in these projects.

The home needs portholes, which take their occupants to other worlds. The communication objects for the future household will need to be based on the way that humans already operate in everyday life.

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Weaving an Interactive Thread:

An Interactive Event for Tales

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Abstract

The Interactive Thread is a set of interactive participatory design activities woven through the Tales conference. This special event has several complementary goals: to encourage Tales participants to collaborate with each other in an interactive event, to share and discuss research methods developed by the interLiving project, and to take advantage of the collective design skills of our colleagues to contribute to the development of disappearing technologies for families.

Keywords: Participatory Design, Interactive Thread, Technology Probes

Overview

The interLiving project explores the design of novel technologies for families, especially those that support inter- and intra-family communication. We normally work with a small number of family members distributed over several households over two or three years, using a variety of participatory design techniques [1]. However, we would also like detailed information from other people. Standard techniques, such as surveys and questionnaires, are useful but provide little of the human context we seek. So our challenge is to find an enjoyable, accessible way to engage a group of people so as to obtain anonymous but real family stories and generate grounded inspirations for design.

[1] Projet In Situ, Pôle Commun de Recherche en Informatique du Plateau du Saclay, CNRS, Ecole Polytechnique, INRIA, Université de Paris-Sud.

Our solution is an Interactive Thread, woven through the conference. (The first Interactive Thread was held at DIS2002 in London; this is the second.) We start with a venue full of interested people, each with families and expertise in interactive system design. Our goal is to capture specific stories about individual families and obtain specific design ideas, using one-on-one or small-group techniques. In exchange, we offer to teach these techniques, in an entertaining, hands-on way. Participants will find this an effective way to meet other conference attendees and discuss their own strategies for developing disappearing computer technologies.

Participants will receive a "Participatory Design Toolkit" composed of a set of 12 printed cards (see appendix). Each describes a participatory design technique, illustrated with a short (15 minute) exercise. We hope Tales attendees will bring these design kits back to their respective projects, either to teach other project team members techniques they may not already know or as exercises for HCI courses.

The special session is organised in three parts. We introduce the Interactive Thread in session 1 and hand out the "participatory design toolkit" and describe a specific design problem. Participants will then collaborate with each other on two data-gathering exercises: creating a relationship map and using a Polaroid camera as a cultural probe. The results will be added to a large poster displayed in the exhibit area.

Between sessions, Tales attendees will be able to experiment with a video-based technology probe [2]. We will distribute personal cards with RFID tags to each participant, which can be attached to different objects, such as a booklet or bottle (fig. 2). Participants will be able to record video (fig.3), comment on other videos, or overlay new messages on top of existing videos (fig.4). Others will be able to use these objects to play previously-recorded clips and append or merge new videos.

Figure 2: Technology Probe

We hope to create an ongoing video thread: a collaboratively-developed story that gathers experiences and ideas from Tales participants while simultaneously demonstrating one of the participatory design methods we use with our families.

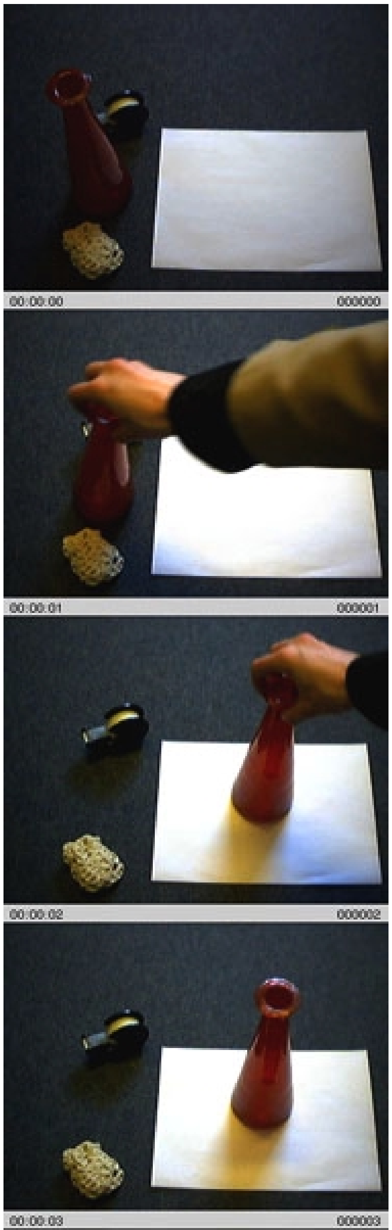

Figure 3: Placing a bottle (with an associated RFID tag) onto the table to record a video clip.

Figure 4: Using a second tagged object to superimpose a second video clip over a previously-recorded clip.

Figure 5: The result of merging a new clip with a previously-recorded video clip.

The closing session will present a brainstorming exercise and the collaborative development of an augmented object. We will also show the results of the earlier exercises and the videos created by the participants in the interim session. We will conclude with a discussion and, if there is time, illustrate the ideas generated by the attendees with a live video prototype [3,4] that reflects a design relevant to disappearing technologies for families.

Conclusion

Our goal is to create an enjoyable, educational experience for DC Tales participants, and at the same time, to provide new ideas and critical feedback to our interLiving project. We think that the best way for people to understand participatory design methods is to actively participate in a collaborative design exercise. We hope to accomplish several objectives with the Interactive Thread:

- Encourage participants to meet each other and discuss interaction design strategies,
- Teach interactive design techniques relevant to all Disappearing Computer projects,
- Test design methods developed by interLiving in a new context, and
- Gather data and design inspirations about family communication.

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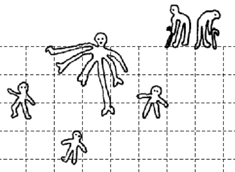
Appendix: Participatory Design Toolkit

Finding out about users : Designers use a variety of sketching techniques to illustrate and communicate ideas, using simple symbols to represent concepts and dynamic events as well as objects.

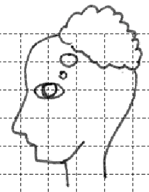
Instructions : Ask a potential user to draw the current relationships between himself and other people in the form of a map, using whatever organizing scheme makes most sense: geographical, emotional, technical, genealogical, etc.



02 RELATIONSHIP MAP

Finding out about users : Designers use cultural probes not only to discover more about users, but also to inspire and engage users in a design discussion. Probes should be open-ended to give both participants and designers a chance to think creatively.

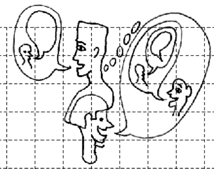
Instructions : Provide a potential user with a disposable instant camera and ask her to take photographs of objects that are relevant to your design problem. Ask her to annotate the photo, explaining why the object is important.



03 CULTURAL PROBE

Generating new ideas : Psychologists developed brainstorming to facilitate creativity. The emphasis is on quantity not quality of ideas. Brainstorming sessions work best with a specific topic, limited time (one hour maximum), a scribe to record every idea and a moderator to ensure that all participate and that ideas are not criticized.

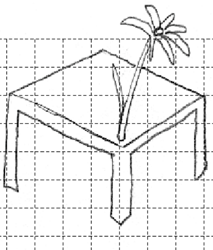
Instructions : Choose a theme relevant to your project and generate as many ideas as you can in 30-60 minutes. Record all ideas and do not discuss them, except to clarify what you meant.



06 BRAINSTORMING

Generating new ideas : Psychologists and designers use techniques such as the "exquisite corpse" to force people to build on each other's ideas. The goal is to create new associations and inspire new design directions.

Instructions : Choose an existing physical object that is relevant to your design problem. Draw the object and then draw a variety of different ways to augment it, using the layers of tracing paper.



07 AUGMENTED OBJECT

1 person: Sketch a map that illustrates the geography of your family and indicate what aspect of their homelife you would like to see.

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2 people : Imagine you could see into your family home right now. What is it it about your home that you wish to see and how? Is it a panorama, close up or a particular point of view? Show this in a photo.

interLiving

4 people : Generate as many ideas as you can about innovative communication technologies for families.

interLiving

1
2
3
4
5
6
7
8
9

4 people : Choose an object to "augment", then draw different examples of how technology might enhance it to help people to communicate.

interLiving

Technology Probes: Inspiring Design for and with Families

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ABSTRACT
We describe a new methodology for designing technologies for and with families called technology probes. Technology probes are simple, flexible, adaptable technologies introduced into families' homes with three interdisciplinary goals: the social science goal of collecting data about the use of the technology in a real-world setting, the engineering goal of field-testing the technology, and the design goal of inspiring users and designers to think about new technologies. We present the results of designing and deploying two technology probes, the MessageProbe and the VideoProbe, with families in France, Sweden, and the U.S. We conclude with our plans for creating new technologies based on our experiences.

Keywords
Design Methods, Computer Mediated Communication, Computer Supported Cooperative Work (CSCW), Home, Ethnography, Participatory Design and Cooperative Design, User Studies and Fieldwork

INTRODUCTION

In his book, *Bowling Alone* [20], Robert Putnam laments the loss of "social capital"– the interconnections we have with our family, friends, and neighbors – in American society. People participate in civic affairs less frequently, hardly know their neighbors, and socialize less often with friends. The HomeNet study at Carnegie Mellon [14, 15] indicates that computers and the Internet can contribute to this problem by isolating people from family and friends and increasing their daily stress levels.

However, this study also suggests that when used for communication, computers and the Internet can play a positive role in keeping people connected – email, instant messaging, and family web sites are just a few of the ways the Internet helps keep people in contact. Thus, people continue to question the value of computer technology in their daily lives [23].

Given this skepticism, it is important to continue to explore if and how technology can be used to support communication with and awareness of the people we care about. In the last several years, there has been an increased interest in both academia and industry in designing technologies for homes and families (e.g. [13, 17, 18]). Such design offers a number of interesting challenges. A huge diversity of ages, abilities, interests, motivations, and technologies must be accommodated. People are much more concerned about the aesthetics of technology artifacts in their home than at work [25], their values may influence their use of technology [24], and playful entertainment rather than efficiency or practicality may be the goal [6].

As part of the European Union-funded interLiving [11] project, we are working together with families from Sweden, France, and the U.S. to design and understand the impact of new technologies that support communication and coordination among diverse, distributed, multi-generational families. Using a variety of research methods from participatory design, CSCW, and ethnography, we have learned about the needs of the families, introduced them to new types of technology, and supported them in becoming partners in the design of new technologies.

BACKGROUND

One of the key objectives of the interLiving project is to experiment with different design methodologies. Each of the authors' organizations has long-standing experience in participatory design [22], which remains the core strategy for the project. However, we each have different experiences and perspectives. Families, and the individuals within them, represent a new user group for all of us. InterLiving provides us with the opportunity to examine our differences, draw from our collective backgrounds, and integrate the most effective approaches.

Motivation

The interLiving partners use methods from the social sciences, engineering, and design. One of our key challenges is to develop new participatory design strategies in which family members can actively participate in the design of new technology. A typical HCI approach would be to interview the families, create a design, develop the technology and then test it to see what the families like or do not like. However, we would like to come up with methods that enable families to more directly inspire and shape the technologies that are developed.

We do not expect the family members to become designers, but we do want them to be active partners in the design process. If we only use the HCI strategy described above, we believe it can discourage active participation by users, as the design concept is already well established by the time the users see it. Their suggestions are likely to relate to details about the user interface and will not be fundamental contributions to the technological design [4].

Our original proposal for interLiving was to distribute "seeding" technologies into the families' homes, to provide families with ideas about what we would like to develop. We expected family members to critique these technologies and provide us with feedback that would affect our subsequent designs. As the project progressed, we shifted to the concept of a 'technology probe', which combines the social science goal of collecting data about the use of the technology in a real-world setting, the engineering goal of field testing the technology and the design goal of inspiring users (and designers) to think of new kinds of technology.

Definition

A well-designed technology probe should balance these different disciplinary influences. On the social science side, technology probes reject the strategy of introducing technology that only gathers 'unbiased' ethnographic data. We assume that these probes will change the behaviour of family members and the character of their inter-family communications. On the other hand, we recognize the benefits of collecting data in-situ and we are interested in observing how their communication patterns and their interpretation of the technology changes over time. On the engineering side, technology probes must work in their intended real-world setting. They are not demonstrations, in which minor details can be finessed. Therefore, all the main technological problems must be solved for the technology probes to serve their purpose.

On the design side, technology probes are similar to cultural probes, introduced by Gaver and Dunne [7], in that they are meant to inspire users to reflect on their everyday activities in different ways. We have used a variation of two early types of cultural probes, providing family members with disposable cameras and diaries and asking them to generate maps representing their family relationships [26]. However, cultural probes tend to involve a single activity at a particular time and do not stress technology per se. Dunne and Raby's Placebo Project [5] 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 explicitly use the technology to collect data about its own use, nor are they asking users to participate in the development of new design ideas.

Our version of technology probes involves installing a technology into the families' homes and watching them use it over a period of time. A well-designed technology probe should be technically simple and flexible with respect to possible use. It is not a prototype or early version of a technology we are seeking to develop. Rather, it is a method to help us and our family design partners determine which kinds of technologies would be interesting to pursue. A successful technology probe is open-ended and should inspire new activities by the family. Once placed in the home, it should encourage family members to experiment with it in ways we haven’t considered and reflect on aspects of how the family members interact with one another.

Because we instrument our technology probes, we can capture two types of data: the use of the probe itself and the relationships within the family. Successful technology probes should be explicitly co-adaptive [16]: we expect the families to adapt to the new technology but also adapt it in creative new ways, for their own purposes. Ideally, technology probes will spark new ideas and help the families articulate ideas for the prototypes we will build.

Features

Technology probes can be distinguished from prototypes or products as follows:

Functionality: Technology probes should be as simple as possible, usually with a single main purpose and two or three easily accessible functions. Prototypes may have many layers of functionality and address a range of needs, not all of which may even be implemented.

Usability: Technology probes are not primarily about usability in the HCI sense, so during the use period, we do not change functions. For prototypes, usability is a primary concern and the design is expected to change during the use period to accommodate input from users.

Logging: Technology probes collect data about relationships within the family and help family members (and us) generate ideas for new technology. We should provide ways of visualizing the use of the probes, which can be discussed by both users and designers. Prototypes can collect data as well, but this is not a primary goal.

Flexibility: Although technology probes should not offer many functionality choices, they should be designed to be open-ended with respect to use, and users should be encouraged to reinterpret them and use them in unexpected ways. Prototypes are generally more focused as to purpose and expected manner of use.

Design phase: Technology probes are intended to be introduced early in the design process as a tool for challenging pre-existing ideas and influencing future design. Prototypes appear later in the design process and are improved iteratively, rather than thrown away.

Implementation

In the interLiving project, we have discussed developing and using a variety of technology probes. Such probes can be used by individuals, groups of family members or everyone in the family. They may be designed for the home or settings outside the home. They may be fixed or mobile, hard-wired or wireless, large or small, new or existing.

Thus far, we have developed and installed two technology probes: the MessageProbe and the VideoProbe, described in the next two sections. Each was designed to gather data about a family's communication patterns while inspiring them to think about new ways of communicating.

MESSAGE PROBE

The MessageProbe is a simple application that enables members of a distributed family to communicate using digital Post-It notes in a zoomable space (Figure 1). It can function synchronously, with two or more family members writing and drawing from different locations at the same time, or asynchronously, with family members checking it periodically for new messages from other households. The probes are connected only to a small set of family members, removing the need for complicated setup and remembering names, addresses, or buddy lists. There is no mouse or keyboard – just a writable LCD tablet and pen.

Hardware and Software

The MessageProbe software was built using Java and three Java-based toolkits: the University of Maryland's Jazz, Sun's Java Shared Data Toolkit 2.0 (JSDT), and Interbind's XIO, all available for download [1,10, 12]. The hardware requirements include a writable LCD display, such as Wacom's PL 500 Series, or a regular graphics tablet, such as a Wacom Graphire, and a regular monitor. The software runs on Windows and Macintosh OS X platforms.

Architecture: We used JSDT to support communication between households. JSDT provides support for collaborative, networked applications with full-duplex, multicast communication. Multiple clients can join and leave sessions to exchange information. Each instance of the MessageProbe is a client that joins a session established by a central server. A separate JSDT registry proces keeps track of the clients.

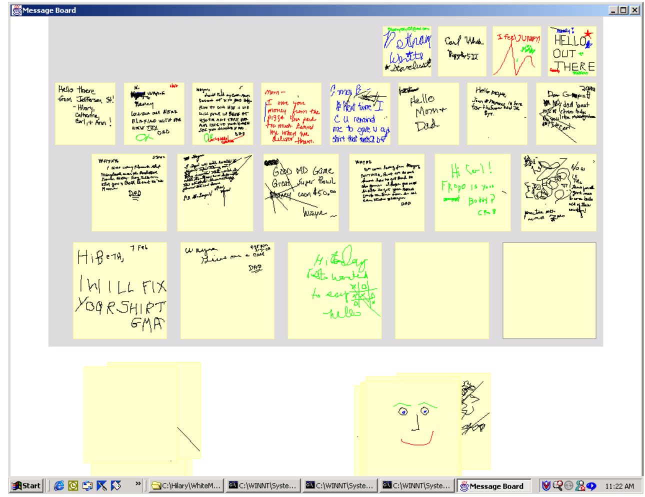


Figure 1. MessageProbe

We used Interbind's XIO to provide robustness in the event of a server failure. XIO is a Java package that can be used to read and write Java objects to and from XML files. The server uses XIO to write out information to an XML file about each message in the session whenever it receives an update. If the server crashes, all of the information can be retrieved from the XML file to recreate the message space.

Logging: In addition to recording the message information in an XML file, we also added a log file to each of the clients. This is a text file that records information whenever family members use any explicit functionality, such as creating a new message or moving an existing message.

Appearance and User Interaction: We used the Jazz toolkit for the spatial arrangement of messages. Jazz provides a two-dimensional scene graph structure for organizing graphical objects in a large, zoomable canvas. Messages are arranged on the canvas in a grid as they are created, with older messages shifted and scaled to less prominent grid positions. Individual messages can be zoomed in or out, and messages can be dragged out of the grid and placed in arbitrary locations on the canvas.

Design

The MessageProbe builds on work from three fields. First, the technology is influenced by synchronous shared whiteboard projects in CSCW [19] and asynchronous commercial communication software such as instant messaging. Second, in an effort to keep remote family members connected, we were also influenced by research in remote awareness [3]. Finally, our interface design is based on past experience with zoomable user interfaces [1]. For more details about the design and related work, see [9].

We decided to build the MessageProbe based on virtual notes because of the popularity of paper sticky notes for informal family communication. We lost the ability to stick notes on anything anywhere in the house, but gained an unlimited supply of notes and the ability to share them remotely with other family members.

With the potential for multiple remote family members to be viewing, manipulating, and writing on their devices simultaneously, there were a number of usability and synchronization issues to consider. Not only do family members at multiple locations share the message space, but also multiple family members at the same location share a single message creation and viewing device.

Thus, we chose to implement a bulletin board-like interface. All users share control of the notes in the message space. Anyone can write on or move a note in the space, regardless of who created it. New notes are immediately sent to all the devices in the family and are displayed in the same location on all devices. We did not want to force an organization of notes on users, but needed some way of arranging them initially. Notes are arranged according to their creation time in a grid, with older notes pushed higher and made smaller.

Organization of notes beyond the default placement is up to users. Notes can be dragged out of the message grid anywhere in the message space. Notes can also be dragged back into the grid, where they resume their place in the time-based order. As notes are added or removed from the grid, the grid reorganizes itself to fill up space. This design allows for some interesting interactions, which add to users' sense of remote awareness. Two users can draw on the same note at the same time or one user can move a note that someone else is writing on.

There is no delete function – users add to existing notes, create new ones, and move old ones. Our original design included these features, plus time and date information for each message. However, in keeping with the design goals of technology probes, we chose to remove these features. Since the idea was that the probe should feel different from a "regular" computer, we tried to take away common visual computer signs, like title bars, borders, bad typography, symbols to click on, etc. With this design, there was no need for complicated interactions or dialog boxes. Users simply tap a virtual pad of notes to create a new one, and then write on it. Tapping on a note other than the one that currently has focus zooms the focus to the other note.

Probe Deployment – U.S. Family

We deployed the probe in the three households of our U.S. family design partners for 6 weeks in early 2002 (Figure 2, left). These households included a nuclear family with two parents and two school-age children, and two sets of grandparents. We provided computers and high-speed Internet access to both sets of grandparents; the nuclear family already had both. While we wanted to provide all of the households with a writable LCD tablet, we only had one of these devices. One set of grandparents used this device, while the other households used graphics tablets.

For both the MessageProbe and the VideoProbe trials, we wanted to be able to place the probes in "high traffic" areas of the families homes, where family members would hopefully look at them and use them often. We were relatively successful in doing this, but we had to respect the families wishes and compromise in some cases. In the U.S. family nuclear and maternal grandparent homes, the MessageProbes were located in the kitchen and main living areas, respectively, both high traffic areas. In the paternal grandparents home, the probe was placed in the basement, which was somewhat out of the way.

Overall, the family created over 120 messages and in all of the households, someone checked the probe at least once a day. The messages were almost exclusively text. The two grandfathers wrote the most notes, followed by the father. The two children wrote a few notes each and the grandmothers and the mother wrote one or two each. The two sets of grandparents didn't communicate with each other; they each just wrote notes to the nuclear family.

Status updates were the most numerous types of notes, but many of these had to do with technology problems. The maternal grandparents had a number of network problems in the beginning. During the course of the trial, the probe stopped working a few times due to server crashes and disk space filling up. Notes about minor news, feelings, and coordination were nearly as numerous, while there were also a few questions and reminders.

The only one who used the probe in the nuclear household regularly was the father. The children were frequently too busy, and the mother preferred the phone. The paternal grandparents had no prior computer experience. The lack of a delete function made the grandfather self-conscious about mistakes, so he wrote many of his notes on paper first. The maternal grandparents had the most trouble with the probe. They required a new modem, a visit from the cable company to get a new IP address, and had a problem with their pen due to electrical interference.

Many of the family members wanted a notification function, such as an audio cue, for new messages. The grandparents were disappointed that the grandkids didn't use it more, but the probe helped reveal that coordination between the nuclear household and the grandparents for childcare was an important issue. However, everyone felt that it was not reliable enough for such important communications. It was fun for writing unimportant things, but the phone was better for a quick response.

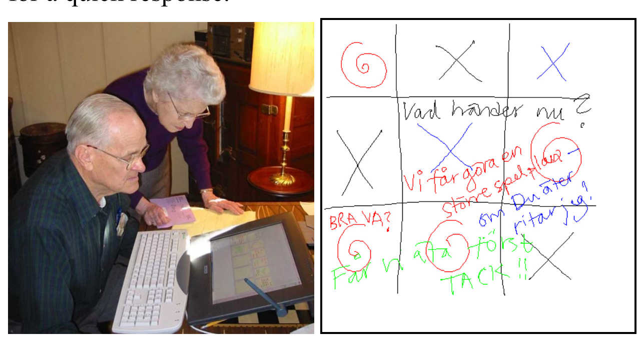


Figure 2. U.S. MessageProbe (left) and Swedish message (right). (Note that the keyboard was not used for the MessageProbe.)

Probe Deployment – Swedish Family

In Sweden, the MessageProbe was installed in two households of one family over several months during the summer of 2002. We provided both households with LCD tablets and Apple Cubes. The households included two sisters, one living with her boyfriend and the other with her husband and two small children.

The first sister and her boyfriend lived in a small apartment and placed the probe in their bedroom, next to their computer. This was a high traffic area, but they chose to switch the probe off at night because of the noise and light it generated. The second sister and her family placed the probe on an unused dining table in the downstairs of their house. The probe was visible from nearly every room downstairs because of the open floor plan in the house.

This family wrote over 200 notes during the course of the trial. There was considerable difference between how much the sisters used it vs. their husband and boyfriend. The sisters treated it as a natural continuity of how they already communicate - a constant flow of notes, with text and drawings, answering machine messages and telephone calls. Their use of the MessageProbe was just another way of leaving notes. By contrast, their husband and boyfriend did not have the same "note-culture" during their upbringing and did not use it as much.

In contrast to the U.S. family, the Swedish messages were more playful (Figure 2, right). One sister played remote "connect-the-dots" with her niece. The two children enjoyed the probe so much that at times they fought over the pen. For the adults, messages were often annotated repeatedly from both sides. When there was no more space to write, they continued on another note.

Like the U.S. family, the Swedish family discussed a visual or audio cue to provide awareness when someone on the "other side" was writing a message. However, they also noted that there was a negative side to such a signal because it could be distracting or annoying if you were occupied with other things. They had similar technical problems with the probe not working at times during the trial, and the zooming feature on their computers was rather slow. In spite of the problems though, they all enjoyed it and said they would miss it if we took it away.

Conclusions

The technology problems prevented the families from developing an adequate level of trust to send important messages using the MessageProbe. Despite these problems, many of the messages in the U.S. family still involved attempts at coordination for things like picking up children and getting together for activities, indicating that this is a promising area of research for new technologies. In addition, the playful use of the probe by the Swedish family indicated a desire for simple, fun ways of providing remote awareness between households. We discuss both of these possibilities in the Emerging Designs section below.

VIDEOPROBE

The VideoProbe (see Figure 3) provides a simple method of sharing impromptu images among family members living in different households. We use a video camera that takes a snapshot when the image it captures becomes steady for approximately three seconds. The images are collected, stored, and made available to anyone else in the network. Family members can browse the images with a remote control. Images fade over time and eventually disappear, to encourage families to create new ones.

Hardware and Software

The VideoProbe consists of an Apple Cube, a Wacom PL-500 LCD tablet, a Philips ToUCam Pro USB camera, a pair of Apple USB speakers, a Keyspan Digital Media remote control, a USB hub and an Apple Airport base for wireless networking. We selected the Apple Cube both for its unconventional look and its silence (it has no cooling fan). Even so, some families complained about the hard drive being noisy. The screen/tablet is used only for display, but we plan to use stylus input in other applications. The Airport base allowed us to install the VideoProbe just about anywhere in the families' homes. The software is implemented in C++ with the videoSpace toolkit [21].

Architecture: We use a client-server architecture, in which all images are exchanged through a central server to simplify maintenance and monitoring. The system launches the VideoProbe software at start-up, allowing the families to restart it without a keyboard or mouse. We can also access the software remotely for maintenance.

Interface: The system can be in one of three modes. When the camera does not detect any motion, it is in passive mode and the screen is black. When it detects motion, it goes into active mode where it tracks motion and waits for a steady image. In this mode, the video stream is displayed at full resolution and frame rate, and it is flipped horizontally so as to behave like a mirror. This helps family members frame a proper image. When the camera detects a steady image, a visual feedback indicates that the system is about to take a snapshot. When the snapshot is taken, an audio feedback is played, the image is displayed full-screen and immediately sent to the server. Note that the snapshots are not flipped horizontally, because family members can take pictures of written notes that need to be readable.

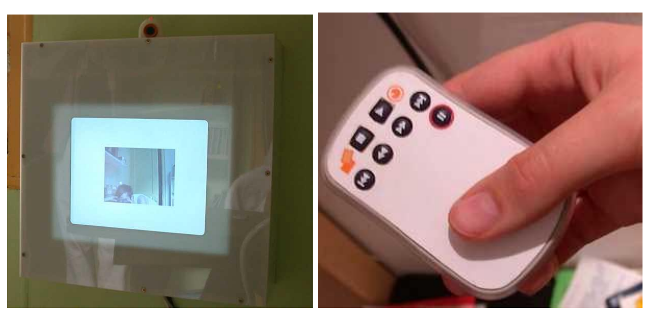


Figure 3. VideoProbe (left) and customized remote control (right)

We use a sophisticated calibration system to handle changes in lighting conditions and camera orientation. When initialised, the system takes a reference shot. Then, it detects movement by comparing successive images. The reference shot is updated as follows: when taking a new shot, the system compares it with the most recent one. If they are similar, the new shot is ignored. If yet another shot is taken that is similar to the previous one, it is ignored and becomes the new reference shot. This approach seems to give good results, with few false positives and false negatives. We calibrated the speed and the amount of time to wait before the system takes a new picture. If an adult wants to pose for a self-portrait, the three-second delay is not a problem. However, children find it difficult to remain motionless for three full seconds so we lowered the threshold for motion detection.

The third mode of the VideoProbe, browsing, is activated when a family member uses the remote control. The next/previous/first/last buttons are used for navigating the stream of images. Images fade out progressively, first by losing their colors, then their contrast. After 2 days, they are removed from the stream (although they are still on the server). One button on the remote is used to save an image in the album, bringing its colors back and stopping the aging process, and to take an image out of the album, re-enabling the aging process. To simplify browsing, all images, including those in the album as well as local and remote ones, are stored in a single chronological file.

Logging: In addition to collecting basic data, i.e. the collection of images saved by family members, we also added a logging system. This records when images are taken and when the family members use any explicit functionality, such as saving an image in the album.

Design

The VideoProbe was inspired by research on mediaspaces [2], which demonstrated the power of video to support remote awareness. We have chosen to share still images rather than live video for several reasons that relate to the goals of technology probes. First, real-time video would have been difficult to achieve in a home installation. Second, still images support asynchronous as well as almost synchronous communication [3]. Third, the design requires family members to interact with the probe, giving us a way to capture usage data and discuss their patterns of use.

Considering the variety of devices and cables involved in the VideoProbe hardware, we had to develop a packaging design that was compact, non-intrusive and simple to handle. We structured the technology into two units: the computer and its power supply and a customised rectangular box that houses the screen and the rest of the equipment. These units are connected via a covered lead, which includes the video, power and USB cables.

The VideoProbe was designed to be usable in a variety of spatial configurations within the families' homes. The box can stand alone on any item of furniture. A hole in the back allows it to be mounted onto a wall, like a picture frame. The unit may also lie flat on its back, so that it can be used for message/drawing applications.

We designed the display unit to exploit the high quality of the screen and video camera. At full resolution, the images do not fill the screen, so we covered the remaining parts of the screen and the rest of the box with white plastic. We wanted to keep the visual design as simple as possible, to blend in with any decor. The white plastic does not attract much attention and naturally disappears into its surroundings when the system is not active. When a family member approaches the VideoProbe, the video fades in and highlights the packaging with a glowing white semi-transparent band, emphasizing the reactiveness of the unit.

The camera sits on top of the VideoProbe screen, similar to a webcam on a monitor. We wanted family members to be able to point the camera in any direction, so we created a notch filled with foam on the top of the VideoProbe. This makes it easy to lift up the camera, rotate it, and fix it into the desired position. The camera can be focused by hand and has a wide range, including objects that are only millimeters away. We provided a long cable, housed inside the box, to enable family members to take the camera out of the VideoProbe to take close up shots of things nearby.

To simplify the use of the VideoProbe, we created a custom-made graphic design for the remote control. Our earlier tests showed that even the few tasks executed by the remote control could be confusing. It was not obvious how to put an image into or remove it from the album, and these actions are not clearly related to culturally-established VCR control iconography, such as <<, >, >>. Note that users also face these problems when attempting to manipulate stored images on commercial digital cameras.

Probe Deployment – French Families

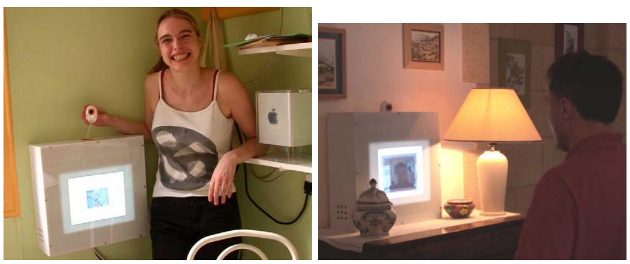
We knew that introducing a new, networked technology into the families' homes would be time-consuming and difficult. The system needed to operate 24/7 and each intervention at a family required several days before we could schedule an appointment and travel to their home. Additional technical and administrative hurdles to install DSL lines at the French families slowed us down. Despite these difficulties, we have installed four VideoProbes in the homes of the French families.

The first pair of VideoProbes was installed in the homes of two sisters, both living in Paris (Figure 4, left). The first sister designed a kind of 'media wall' for the probe in the corridor of her flat, due to the lack of space in the apartment. The corridor was designed as a substitute for a social lounge area and the VideoProbe fit very well into this environment. The second sister and her roommates let us drill a hole so we could place the VideoProbe on the wall. They also moved things around and were interested in finding a location that was integrated into their living space.

Unfortunately, she had to move soon after we connected the probe so we could only collect limited data.

The second pair of VideoProbes was installed in the homes of two brothers, both living in suburbs of Paris (Figure 4, right). These families decided that they wanted to place the VideoProbes in the main living area, where they could be seen from both the sofa and the dining room table. Unlike the two sisters, the settings were more formal and it was not possible to hang the probes on the wall. Instead, the families placed them on tables or sideboards, rearranged to accommodate plants, vases, and lamps.

Preliminary observations of the use of the VideoProbes already show a variety of patterns of use. Kids and young adults like to use it in a playful way, e.g. sending pictures where they make faces or taking strange close-ups. They also use it for communication purposes, e.g. taking a picture of a hand-written message. We expect these patterns to evolve when the probes are used over a longer period of time and become more integrated into the families' lives.



Figures 4. VideoProbes in the French families' homes

EMERGING DESIGNS

Our experiences deploying the MessageProbe and the VideoProbe in the homes of our family design partners has led us to two promising areas of research. Through log files, interviews, and workshops, the families have identified a variety of different interests, from practical to whimsical, for staying in touch with members between and within households. We are developing two types of prototypes that reflect this diversity: some to support family coordination and some to support playful interaction.

In addition, we have realized that families need a far better method of specifying with whom they communicate. To meet this need, we are exploring different approaches that will be integrated into our prototypes. Finally, our experience installing the probes to fit around existing objects in the home suggested that we should explore applications that take advantage of existing objects. We are designing our prototypes to address this need, by studying which objects in the home can be augmented to support coordination and playful interaction.

Family Coordination

The first conclusion we and our design partners drew from the technology probe installations was that coordination between and within households is important but difficult. Following the U.S. MessageProbe trial, we held a workshop with the U.S. family households in April 2002. The goal of the workshop was to brainstorm about ideas for family communication and coordination technology.

We motivated the discussion by discussing examples and events of coordination scenarios and breakdowns that we had learned about through the MessageProbe trial. We split the family into teams and gave them low-tech prototyping art materials (colored paper, string, clay, etc.) to use to design technology solutions for the scenarios.

The mother and father wanted to keep track of everyone's schedules. They built shared calendars embedded in the refrigerator and added features to their cell phones to connect them with this calendar. The grandparents wanted to keep track of people. They built key hooks by the door that noted who was home, and a ring that pinched the wearer if someone wanted to talk to them. The kids wanted small devices for keeping in touch with friends and parents – voice activated key chains for sending messages and watches that displayed after-school activities.

Overall then, staying connected with and aware of family was important, but people had different motivations for doing so and wanted to do it in different ways. As a first step to supporting them, we are developing new calendar interfaces to enable households to view each other's schedules. Later, we could extend this service to improve communication, portability, and tracking by supporting GPS-equipped PDAs, cell phones, and other small devices.

Family Playfulness

The second conclusion that became clear after the deployment of both the MessageProbe and the VideoProbe is that families want to have fun together, even at a distance. With the MessageProbe, we saw tic-tac-toe boards, connect-the-dots games, and family member caricatures, all bringing family members from different households into shared, playful activities. With the VideoProbe, early interactions included family members making funny faces at each other at a distance.

This is not a startling conclusion – Huizinga coined the term Homo Ludens in 1950, defining humans as playful creatures [8]. However, aside from games, the design of technologies has generally focused on tools to improve our efficiency, not to support our playful side. It is only recently that designers such as Gaver have begun to think about how to design to support playfulness [6]. Our technology probes build on his suggestion that the design of playful technologies be open-ended and ambiguous to inspire new uses, and the fun ways our design partners interacted with the probes seem to validate this approach. We are currently working on prototypes that build on these ideas.

CONCLUSIONS

We believe that technology probes are a promising new design tool for working with families as partners in the design of new technologies. Despite the technical difficulties encountered during the deployment of the

MessageProbe and VideoProbe, we believe that as technology probes, they were successful in three ways.

First, they helped reveal practical needs and playful desires within and between distributed families. Second, they provided real-life use scenarios to motivate discussion in interviews and workshops. Finally, they introduced families to new types of technologies beyond the accustomed PC-monitor-mouse-keyboard setup, which we believe encouraged them to consider more whimsical and creative uses of technology in our design workshops.

ACKNOWLEDGMENTS

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VideoProbe: Sharing Pictures of Everyday Life

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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.

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 (Greenbaum & Kyng, 1992) 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 (Hindus et al., 2001). 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. (2002) point out, 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 (Hutchinson et al, 2003), 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 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" (Orlikowski, 1992) 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 (Hutchinson et al, 2003) 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.

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

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.

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.

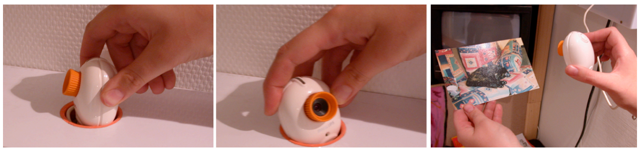

Figure 2: The video camera can be turned or used to actively take a photograph of a particular object.

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).

Figure 3: VideoProbe and its remote controller.

2.2 Software description

The videoProbe software is written in C++ and uses the videoSpace toolkit (Roussel, 2001), 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.

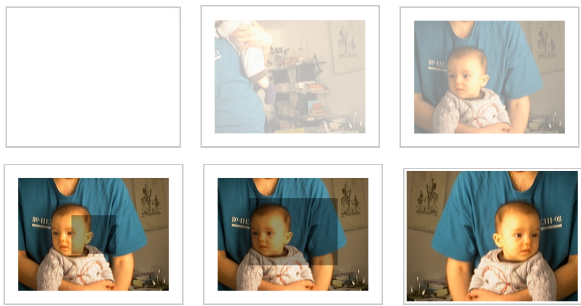

Figure 4: Screenshots of videoProbe's camera mode.

The interface provides feedback about the remaining time before taking a shot. When videoProbe detects a lack of motion, a grey 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.

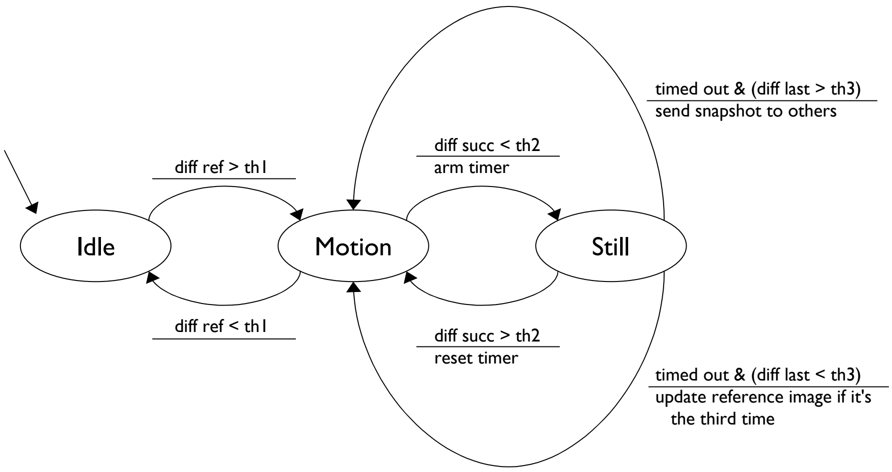

Figure 5: Simplified version of the scene change detection algorithm.

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* > th*x*" states that the condition is true if the difference between the last grabbed image and the image *img* is greater than a threshold thr*x*. 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 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.

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

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 Mulhouse, 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 Mulhouse. 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.

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	19:52:03---	previous image	
House2	4-Apr-03	Fri	19:52:05---	put in album	2003-04-04-07-53-13-House1.jpg

Figure 7: Sample of data log, showing user actions and links to pictures

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% of the pictures contained people. We discovered that lighting changes generated most of the others, so we adjusted the videoProbe's sensitivity. We also identified 3% that resulted from turning the camera to the wall. The family explained that they did this for privacy, for short periods of time. 18% of images contained several family members and 9% showed a person on the telephone.

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 video link 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 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 screen-play 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 accidentally 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 hand-written 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 (Roussel et al., 2004) 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 (Mackay et al, 2003), 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 video clips captured with a local camera 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).

Figure 8: StoryTable has a tangible interface to record and share video clips.

4.3 Testing in the real world

Installing the videoProbes and maintaining 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 accidentally 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, browser mode requires explicit interaction to navigate and save images. We could, in fact, make the browser autonomous 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 support 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 (1996) refer to as *calm technology,* 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 appliance is Strong & Gaver's (1996) feather, 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 (Mynatt et al., 2001) obtain sensor information from a remote senior house and present it as a "qualitative reflection of his or her activity level". Hindus et al. (2001) 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 (Fogg et al., 1998) lets remote users play together. If someone physically moves a ball in one location, the distant ball moves as well. Hart2Hart (Grimmer, 2001) allows two people wearing digitally-enhanced vests to exchange a "remote embrace" using touch to wirelessly convey heat, pressure, and heartbeats.

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 Mackay, 1999 for an overview). For example, Portholes (Dourish & Bly, 1992) provides group awareness over a distributed work space 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 (Mynatt et al., 2001), which display information in the background without explicit interaction. However, videoProbe requires more interaction, especially while browsing images. Ceiva (http://www.ceiva.com) 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 (Gaver et al., 1999) - 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 (Hemmings et al., 2002, Westerlund et al., 1988) . However, cultural probes tend to involve a single activity at a particular time and are not necessarily technologies themselves. The Placebo Project (Dune & Raby, 2001) 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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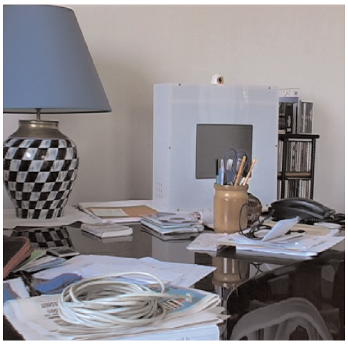
2. Prototypes



Paper section 2.
Prototypes

Here we describe three shared surfaces prototypes developed during years 2 and 3.

2.1. Mirror Space

MirrorSpace is a video communication system that uses proximity as an interface to provide smooth transitions from general visual awareness to very close and intimate forms of communication. The paper contains an overview of the design concept of MirrorSpace, some details of its implementation and some initial user reactions to this system and directions for future research.

2.1.1. Roussel – Evans – Hansen: MirrorSpace: using proximity as an interface to video-mediated communication. Accepted for Pervasive 2004, April 2004.

2.2. Disappearing Ink – InkPad

The basic ideas of the InkPad are that you draw and write on it with ink and the inks are constrained by time. Some ink can disappear after a specific time, some other appear after a certain time, some other occur at certain regular or irregular times. In the first paper the Constrained Ink Metaphor is described, discussed and typical applications described. In the second paper the development and use with close participation of several family members is described and analysed.

2.2.1. Eiderbäck – Westerlund – Lindquist: The Constrained Ink Metaphor, Proceedings HCI International 2003, Heraklion, June 2003, 5 pp.

2.2.2. Lindquist - Westerlund: InkPad development and use. Draft version to be submitted after more family experience and reworking.

2.3. Shared Family Calendar

Using technology to allow multiple households to view each other's schedules seems to provide a good part of the remote awareness families desire. In the paper is demonstrated a system facilitating the sharing of calendar information between remotely located family members.

2.3.1. Plaisant – Bederson – Clamage – Hutchinson – Guimbretière: Shared Family Calendars: Promoting Symmetry and Accessibility, work in progress for submission.

MirrorSpace: using proximity as an interface to video-mediated communication

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Abstract. Physical proximity to other people is a form of non-verbal communication that we all employ everyday, although we are barely aware of it. Yet, existing systems for video-mediated communication fail to fully take into account these proxemics aspects of communication. In this note, we present MirrorSpace, a video communication system that uses proximity as an interface to provide smooth transitions between peripheral awareness and very close and intimate forms of communication.

1 Introduction

Physical proximity to other people is a form of non-verbal communication employed everyday by us all, although we are barely aware of it. We constantly use space and distance to define and negotiate the interface between private and public matter, particularly during the moments leading up to contact. By altering our physical distance from other people in a space, we communicate subtle messages such as our willingness to engage into dialogue with them, the desire for more intimacy or a lack of interest.

The term *proxemics* refers to the study of spatial distances between individuals in different cultures and situations. It was coined by E.T. Hall in 1963 when he investigated man's appreciation and use of personal space. Hall's model lists four distances which Northern Americans use in the structuring of personal dynamic space [1]: *intimate* (less than 18 inches), *personal* (between 18 inches and 4 feet), *social* (between 4 and 12 feet) and *public* (more than 12 feet). For each communication situation, there is a distance within these four categories that we find appropriate, based on our cultural background and on the particular context of the situation. If the perceived distance is inappropriate, we become uncomfortable and we usually adjust it by physically moving closer or further away, or even simply turning our head or looking in another direction.

Existing systems for video-mediated communication fail to take into account the proxemics aspects of communication. Although some of the people who designed the systems understood the importance of these aspects, they failed to fully provide the support they require. In this note, we present MirrorSpace, a video communication system that uses proximity as an interface to provide smooth transitions between peripheral awareness and very close and intimate forms of communication.

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2 Related work

Most video communication systems are based on a glass pane metaphor. VideoWindow [2] probably best illustrates this concept, displaying remote people as life-sized images on a large vertical surface, making them appear as if they were seen through a virtual window. The glass pane metaphor provides a sense of shared space and supports gesture-based communication. However, even with life-sized images, the psychological distance to someone at the other end of the system is still greater than that in a comparable face-to-face situation. In particular, the distance between the camera and the image of a remote person's eyes can make eye contact and gaze awareness a real challenge. A number of solutions to these problems have been proposed for specific contexts. ClearBoard [3], for example, supports both eye contact and gaze awareness in close collaboration situations based on shared drawing.

As a cultural artifact, the mirror has a prominent position in the creation and expression of esthetics. Throughout Western culture narratives such as the Narcissus myth, *Snow White* or *Through the Looking Glass*, it has come to many different meanings including vanity, deception, identity or a passage to another world. A number of interactive art installations, such as Liquid Views [4], have picked up on these meanings and taken advantage of the universal and irresistible fascination for self-image. A mirror metaphor offers an interesting potential to attract people to a video-based system [5]. It also helps reduce the psychological distance between local and remote participants by displaying them side-by-side, as if they were all in one room [6].

No matter the metaphor, the interpersonal distance perceived by participants determines in great part the suitability of a video communication system for a particular context. ClearBoard, for example, creates the impression of standing about one meter away from the other person, which corresponds to the personal distance of Hall's classification [3]. Although perfectly suited for use with friends and colleagues, this distance might seem too small for a formal meeting with a person of a higher rank. Another consequence is that while ClearBoard makes it easy to establish eye contact, it also makes it difficult to avoid. Users of VideoWindow experienced the same problem and "went to great lengths to avoid eye contact" when they wanted to avoid conversation [2].

ClearBoard authors suggest that the communication system could provide users with some control over the perceived interpersonal distance [3]. This distance is influenced by many factors such as the spatial distance from the display, the size and quality of the video images, backdrops or voice fidelity. The potential exists for proximity as a form of non-verbal communication to affect behavior in video-mediated interactions. Yet, very little work has been carried out on the control over perceived proximity [7].

3 MirrorSpace

While existing video communication systems create a shared space corresponding to a particular interpersonal distance, the goal of MirrorSpace is instead to create a continuum of space, to allow a variety of interpersonal relationships to be expressed. Our work focuses on the understanding of how people's interactions can trigger smooth transitions between situations as extreme as peripheral awareness of remote activity and intimate situations.

MirrorSpace relies on the mirror metaphor. Live video streams from all the places it connects are superimposed on a single display on each site so that people see their own reflection combined with the ones of the remote persons. A real mirror is already perceived as a surface for mediating communication with its own rules and protocols. As an example, making eye contact with a stranger through a mirror is usually considered less intrusive than direct eye contact. Since the mirror is already associated to this idea of reaching out to other people and other spaces, we believe it is the ideal enabling metaphor for establishing a new communication experience.

As we aim to support intimate forms of communication, it felt important to us that people could actually look into each other's eyes, so the camera was placed right in the middle of the screen. This setup allows participants to come very close to the camera while still being able to see the remote people and interact with them. MirrorSpace also includes a proximity sensor that measures the distance to the closest object or person in front of it. A blur filter is applied on the images displayed to visually express a distance computed from the local and remote sensor values. Blurring distant objects and people allows one to perceive their movement or passing with a minimum involvement. It also offers a simple way of initiating or avoiding a change to a more engaged form of communication by simply moving closer or further away.

MirrorSpace was originally conceived as a prototype for the interLiving project[1] of the European *Disappearing Computer* initiative. A first video mock-up illustrating its design concept was made in August 2002. Several units were then created and presented to the public as an interactive video installation in four art exhibitions, in February, May, July and December 2003.

3.1 Hardware configuration

Two MirrorSpace units were built for the first exhibition and slightly modified before the other ones. Each unit consists of a flat screen, a camera, a proximity sensor and a computer that runs dedicated software. These prototypes have been designed to minimize their technological appearance so they can discreetly blend in their environment. The computer and the wires are kept hidden from users. The screen and its attached sensors are placed into a wooden box, protected by a transparent glass partially covered with a real mirror film (Fig. 1).

The image sensor and the lens of a Philips ToUcam Pro have been placed in the center of the screen. The sensor is connected back to the logic board of the camera using hair thin isolated wires running over the screen surface. Informal tests quickly confirmed that the lens is hardly noticeable once placed onto the screen, since people are generally focused on the images displayed rather than the screen itself. The proximity sensor, a Devantech SRF04, has been placed at the bottom of the screen. It is connected to a Parallax BASIC Stamp chip, itself connected to the computer via a serial interface. The computers were initially Apple PowerMac Cubes. They were later replaced by 2.8GHz Pentium IV machines with 2GB of memory and an NVIDIA GeForce FX 5200. A 100 Mbits/sec Ethernet network was set up to connect them during the exhibitions.

[1] http://interliving.kth.se/

Fig. 1. MirrorSpace installation for the second exhibition

3.2 Software

MirrorSpace software is written in C++. It uses the videoSpace library [8] to capture SIF images from the camera in real-time and OpenGL to display a graphical composition created from these images and the proximity sensor values. Although only two were used for the exhibitions, the software doesn't make any assumption on the number of connected units. Proximity sensor values and images are sent on the network with a best-effort strategy (images are transmitted as JPEG data compressed to fit in a single datagram). The compositing process applies a blur filter on the image of each unit and superimposes them using alpha blending. The resulting composition is flipped horizontally before display to produce the expected mirror effect.

The blur effect is implemented with a two-pass incremental box filter. The size of the filter (i.e. the number of neighbors taken into account for one pixel) determines the blur level. The sensor values of all connected units are used to compute the size s of the filter to apply to each image. Three computation modes have been investigated so far. The first one (1) only takes into account the distance d, measured by the unit that captured the image. The two others (2 and 3) also take into account the distance d_{loc}, measured by the unit that displays the image:

$$s = f(d) \tag{1}$$

$$s = f(d_{loc} + d) \tag{2}$$

$$s = f(|d_{loc} - d|) \tag{3}$$

The software allows to choose a different mode for each unit. However, a strict WYSIWIS condition (*What You See Is What I See*) was imposed for the exhibitions.

4 Interacting with MirrorSpace

The first mode of operation of MirrorSpace (1) is quite intuitive: objects and people close to the mirror are better perceived than those far away. It is the one we used for all the exhibitions. It allows people to slowly get into focus as they move closer to the unit (Fig.2) and out of focus as they move away from it. The second mode introduces the notion of relative distance between participants. By moving forward or backward, people alter not only their own image but also the image of the remote persons. By moving away from the mirror, one can still slowly disappear. However, in this case, the other people can follow that person to a certain extent. The third mode should allow multiple ”islands” of communication aligned in front of the sensor. However, a lot of space and more than two units are needed, which is why it hasn’t really been tested yet.

Fig. 2. Moving from peripheral awareness to focused communication by approaching the mirror

Almost all visitors of the exhibitions agreed on one point: interacting with MirrorSpace is fun. Proximity sensing helps creating an intimate relationship between users and the system. Many of them played with their own image and the blur effect. People didn’t hesitate to make a fool of themselves and many took pictures or recorded video clips of themselves and other people interacting through the system. When they saw another person appearing next to them on the screen, many people turned over, looking for that person behind them. This shows that the superposition of the images creates a sense of sharing the same space. It also shows that MirrorSpace is perceived as a mirror and not as a remote video communication system. In fact, the majority of the people didn’t think about the camera at all. Only after playing with the system for some time, they suddenly asked surprised ”where is the camera?”.

The superposition of the images allows not only to share space but also to become one. People who were visiting the exhibitions with friends or relatives immediately understood that and tried to overlay their faces (Fig. 3). Some went as far as kissing each other. At the same time, other persons were surprised and even disturbed to find strangers able to come so close to them. In that case, they simply backed away, which made their own image disappear smoothly with the blur effect. This strongly differs from systems such as ClearBoard or VideoWindow where eye contact is difficult to avoid. It shows that MirrorSpace can be used as an intimate communication device and, at the same time, supports at least part of the body language we are used to.

5 Conclusion

We hope that MirrorSpace will help researchers and practitioners realize the importance of the understanding of proxemics for the design of video-mediated communication

Fig. 3. Close and intimate communication through MirrorSpace

systems. The design concept of this system as well as some details of its implementation have been described. We have also described some user reactions to presentations of the system that were made during several art exhibitions. These initial reactions show that MirrorSpace supports smooth transitions between peripheral awareness and very close and intimate forms of communication. We strongly believe that the use of proximity as an interface to computer-mediated communication is a promising research direction. We plan to continue this work on image-based communication and to apply the ideas described in this paper to other forms of communication as well.

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The Constrained Ink Metaphor

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Abstract

In this paper we describe a novel metaphor for developing interactive computer applications, *the constrained ink metaphor*. Crucial to the development of the constrained ink was an aim to find simple and natural means for defining and implementing interaction among persons. We will describe how we was lead to considering this metaphor, some basic inks following the metaphor, and finally some typical applications and their impact on the development of the metaphor.

1 Background, Goals and Influences

1.1 The interLiving Project

The interLiving project aims to study and develop, together with families, technologies that facilitate generations of family members living together with the objectives: to understand the needs of diverse families; to develop innovative artefacts that support the needs of co-located and distributed families; to understand the impact such technologies can have on families (Beaudouin-Lafon, 2002, Hutchinson, 2003).

1.2 Goals and Research Questions

A key objective of the interLiving project is to experiment with different design methodologies. We would like to develop better ways of letting the family members directly influence and shape the design of communication technologies we develop together with them.

The *premiere goal* with the particular work described in this paper is: to develop an infrastructure and metaphor that will enable us to build applications were we leave as much us possible open to the co-development with families, even late in the development process. *Secondary goals* are: i) that it should be easy and natural to develop all our intended applications by means of this infrastructure and metaphor; ii) that the metaphor should encourage development of applications that are fun to use (and develop!)

Research Questions are:

- Is it possible to create an infrastructure and metaphor of the type we strive for in the goals?
- For which types of applications is the metaphor well suited and for which types is it not naturally applicable?

1.3 Technology Probes

As inspiration and triggering techniques we have used technology probes. A 'technology probe' combines the social science goal of collecting data about the use of the technology in a real-world setting, the engineering goal of field-testing the technology and the design goal of inspiring users (and designers) to think of new kinds of technology (Beaudouin-Lafon, 2002 Chapter 2). The probe that influenced the development of the applications we currently are working on most is *The Message Probe*, a simple application that enables members of a distributed family to communicate with digital notes using a pen and tablet interface. Already at early stages of the development of applications inspired by these probes we realized that we required something that both was fun to use and easily adoptable to various and changing requirements. This in turn led us to the development of *The Constrained Ink Metaphor*.

1.4 Influencing Approaches

There are of course a lot of achievements in the history that has inspired, or at least influenced, our development. For instance Ivan Sutherlands pioneering work on Sketchpad (Sutherland, 1963), the NLS system in the SRI project (Engelbart, 1975), the very direct manipulated A Reality Toolkit (ARK) (Smith, 1987), editors for drawing and animation like Macro Mind Director, Calendaring facilities (Beaudouin-Lafon, 2002), and the more recent KidPad (Benford, 2000). We have also been inspired by work done in CSCW and design patterns (Eiderbäck 2001).

2 Ink of Various Kind and their Usage

2.1 The Metaphor: What, Why, and How

The constrained ink metaphor is a novel metaphor for developing interactive computer applications. The idea of it sprung from an attempt to develop a common base for a message central and a distributed shared drawing editor, intended for communication between family members possible living in different households. In the former case we focus on the same place different time aspects were we want to provide for submitting shared notes visible within certain time frames. In the latter case we focus on same time different place aspects were we for instance want to provide for co-operative drawing, communication and address awareness aspects. Our intention is to enabling communication of both important facts and more informal chatting in a way youngsters, adults, and elder members of the family, computer literate or not, could find useful and “fun”! We discussed the concept together with the families and agreed that it seemed to be promising, useful and fun.

2.2 Ink

Central to the Constrained Ink Metaphor, as its name suggests, is the Ink!

2.2.1 Natural Inks

There are a lot of different types of ink that could be considered natural in the sense that they more or less have their counterparts in the real world. For instance, we have the invisible ink that even a small children most likely have experiences from using a special purposes pen with ink that only appears after one heat the paper it is written on. Another natural ink is the aging ink; actually this is the way all inks work, where the ink slowly disappears from the material it is written on. However in our computerized versions we have speeded up and made the aging more controllable.

The Coloured Ink

As a basis we use ordinary coloured ink, i.e. all inks have a defined colour or texture. On top of this basic ink all the other inks was developed, by applying various constraining schemas that made them behave and response to external events.

The Invisible Ink

The Invisible Ink is the most natural of all the constrained inks.

> ***Context***
> The user wants to write a note that should be presented at a specified time in the future. Thereafter the note should stay until someone actively removes it.
>
> ***Problem***
> How could we provide model providing a means to construct entities that should appear at a specific time in the future? How could we develop a model that fits into and is suitable for all the various applications we are developing within the project?
>
> ***Forces***
> The model should be natural to use. The usage of the model should not constrain the process or the interaction. The model should be natural for handling constrained entities of various kinds as graphical one, e.g. lines and ovals, and non graphical ones, e.g. email and speech. It must be feasible to implement the model in software.
>
> ***Solution***
> Make a computerized version of an invisible ink. For convenience for programmers incorporate the ink model into the system's ordinary model of drawing with various colours and textures, i.e. it should be possible to use the ink for colouring objects even in "non-ink aware" applications. Therefore separate parts for handling the interaction with the ink from ones handling its behaviour and ones handling its visible appearance. In this way one could easily change or adopt new behaviour to ink and at a very fined grained level control its constraints.

The Aging Ink

The Aging Ink is ink that disappears after a pre-defined time. It works as ordinary ink, but we have speeded up the decaying process and also made it more abrupt.

> ***Context***
> The user wants to write a note that is valid from the time the note is written until a certain time in the future.
>
> ***Problem and Forces***
> The problem forces are the same as for the Invisible Ink but now the entities should disappear after a while instead.
>
> ***Solution***
> The solution follows the same lines as the one for the Invisible Ink. With the separation of controlling and behaviour from appearance we only has to replace the constraint controller for one that makes the ink disappear after a certain time, instead of appear as for the former ink.

2.2.2 Generally Constrained Inks

After discussing applications, and reflecting on our earlier prototypes among ourselves but also with our families we considered the ink metaphor in more dept. We realised that the natural inks would not solve all the problems that we intended. We require to entities responding to general events, as someone pushing a button or joining a family's network. Therefore we decided to expand the metaphor further to see if it could be useful even in ways that not have their direct counterparts in ink from the natural world.

2.2.3 Asymmetric Inks

We also want to be able to show things differently, or at different times, at diverse platforms. Sometimes everything should be visible to all users in the same way at other times some parts are not visible to all users or just presented differently to some of them. Entities could even be handled on dissimilar platforms and by different media by various users, i.e. on use speech at a PDA whereas another user has a graphical platform with a text interface. Therefore we try to investigate the impacts these situations has on the ink and try to develop ink that also are suitable for them.

2.2.4 Inks Intended for Sharing

In some senses we could use the previously described inks for sharing. We have inks visible at all platforms, inks that appear differently for diverse users, etc. However, only relying on these inks makes sharing of artefacts required in a more general sense very clumsy. To address this we have played with inks that could define certain (filled) areas where all other inks painted on the area should be visible by a shared and connected community. Thereby we could easily, within the limits of the constrained ink metaphor, even provide for shared desktops and other means of co-operative work. Therefore we also investigate how this type of ink is usable and fits into the metaphor.

3 Some Typical (Ink Based) Applications

3.1 Type of Application

The applications we currently are working on affect the type of ink required in different ways. In this section we very briefly exemplify of the various types of applications we consider. These considerations are a basis for our further development and exploration of the constrained ink metaphor. Some typical kinds of applications are:

- *Synchronous vs. Non-Synchronous Applications.* There is an obvious difference between synchronous and non-synchronous applications. In the former case communication takes effect momentarily whereas the latter case is more indirect, probably taken its way via some server, storage medium, or alike.
- *Shared vs. Non-Shared Applications*. Another situation we must consider is if the application should be shared, i.e. everyone manipulates a shared set of entities, or non-shared where different users could manipulate their own restrictive set of the entities.
- *(Just) Graphical vs. Multimedia*. Typical shared applications of today also provide for other media than graphics. Examples are telephony over IP, and videoconferences.
- *Sinking Ships*. An archetypical application where different users at certain times sees different parts of the entities or even presented in different ways is the famous game Sinking Ships.

3.2 Applications

Currently we are focusing on two different applications. The InkPad and the Door. We also explore some types of interaction, not central in the other two, in a Pie Diagram framework. In the sense of exploring the constrained ink metaphor the InkPad is the most central and new kinds of ink and constraints are first tested within this application.

3.2.1 A Shared (Drawing) Editor, InkPad

The InkPad is a tool with the main aim to enabling free and non-formal communication among family members of all ages. To support free communication we try to make InkPad an as relaxed environment as possible. The focus on this prototype is on enabling communication of both

important facts and more informal chatting in a way both youngsters, adults, and elder members of the family, computer literate or not, could find useful and “fun”.
The user could choose ink from any of the previously described types of ink. In this way the user could achieve effects as writing messages and notes that will appear or disappear at specific times. We have also considered other media, such as audio, video, and speech.

3.2.2 Message Central, the Door

We also develop a message central nick named *The Door*, from the first intended placement in the household. The Door prototype is an effort to improve the communication and scheduling of activities among family members. At the start we concentrate on communication between members living in the same household. In this case we use the ink metaphor for controlling and delivering messages.

3.2.3 Pie Diagrams

Pie Diagrams are just like ordinary pop up menus but circular. In particular we investigate how invisible ink could be used to supporting expert users that now the relative location of certain submenus and the items they want to chose. The ink is constrained to only paint a certain sub-pie if the user “fires a certain event”, by for instance stopping the movement more than a pre-defined time limit. In such a case the ink reacts by switching from transparent colour to non-transparent ones and thereby makes the pie visible.

4 Conclusions and Future Work

In this paper we have described the *Constrained Ink Metaphor* by describing various forms of (constrained) inks and their usage. We demonstrated that the metaphor is both natural and useful for developing a various set of interactive and distributed applications.
From now on we will investigate the metaphor further by using it to full extent while continuing the development of a various set of applications within the interLiving project.

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InkPad development and use

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In order to understand communication and technology use we have used a variety of methods. Earlier we have developed technology probes that gave us input in understanding the families and their technology use, how the individuals create meaning with the technology around them (interLiving Deliverable D 1.2 & 2.2). Here we describe cooperative prototyping work. The role of prototypes is to investigate aspects of the future situation of use. The following text is about paper and software prototyping work, as input (in an iterative process) to the design and the design process.

Design aspects / Inkpad Prototypes

Since this is a cooperative design project the InkPad is naturally designed in close cooperation with the users. This is opposite to when we developed the technology probes earlier (D 1.2 & 2.2) In order for the probes to work as probes the users could not be involved in the design of them. Although some technology probes and prototypes seem similar, like the messageProbe and the InkPad, their role in the design process is different. The technology probes roles are the social science goal of collecting data about the use of the technology in a real-world setting, the engineering goal of field-testing the technology, and the design goal of inspiring users and designers to think about new technologies. One of the ideas that evolved was the InkPad.

The InkPad concept needs to have all of its aspects carefully considered, used and tested by our families in the appropriate context. The role of prototypes is to investigate aspects of the future situation of use. Most prototypes focus on a few aspects to make the analysis easier. But it is important to be aware of all feedback.

Intentions

Our intention with the InkPad is that, besides facilitating communication, it shall feel more like an appliance, like a toaster, than a computer to the users. Our interest is to facilitate the human-to-human relations. The artefact itself, hardware and software, should cause as little resistance as possible to the family members, to make use meaningful. Several models are available to support the design work and three will be mentioned here. Janlert and Stolterman (1997) describe the importance an expected character has on making an artefact easy to use. Bill Gaver (1991) and Norman (1988) have given us insights on Gibson's (1982) concept of affordance in relation to the use of everyday artefacts. Klaus Krippendorff and Reinhardt Butter have helped us a great deal regarding the concept of product semantics (1984, 1992, 1995).

The ideal would be if the users feel that the InkPad's character fits into the context in the household, visual and other. Since the households that these are installed into have different characters, as discussed in D1.1, we had to decide what strategy we should have. We could try to make individually designed InkPads for the different households or we could make one that would go into all households. There are different advantages and drawbacks with the two approaches.

Figure 1-4. One version of a paper prototype. This prototype was designed to reveal communication issues that the persons found meaningful. Top left: message written. Top right: The person that the message was intended for answers on a transparent sheet of plastic. Bottom left: the author of the first message writes OK to show that he has seen the message. Bottom right: Different cards that were used in the workshops following the use of the prototype. They were intended to grasp issues that were not revealed otherwise, like what common knowledge do the people have that is essential for the communication to work?

Beside this aspect of fitting into the visual context, if the user constructs an appropriate character, the technology might be easier to use because the expectations will be fulfilled (Janlert, 1977). Therefore we tried to avoid many of the common computer signs, like a keyboard, a mouse and on the display title bars, borders, menus, etc. But we did not only consider the visual signs, we also chose a computer without a fan, the Apple Macintosh Cube, to minimise the noise, a typical computer sign. And besides being possible to construct a signification to computers, the noise is a property that we do not want anyway. We want the appliance to be running and available all the time.

"... the concept [of affordance] is a powerful one for thinking about technologies because it focuses on the interaction between technologies and the people who will use them." "Affordances exist whether or not they are perceived, but it is because they are inherently about important properties that they need to be perceived ..." (Gaver, 1991: 80)

The design work should of course help the users perceive the affordances available and the signs that the users construct are the keys to achieve that. We work hard to simplify and minimize the interaction with the machine and instead emphasize the human-to-human interaction.

Below we will describe the still continuing prototype work with all the families moving towards the inkPad, but with different a focus on the inkPad depending on the different families needs and desires.

Prototyping

Workshop with Red family

From the very beginning of our acquaintance with the Red family, their wish for "some sort of central that helps us with communicating information and coordinating people" has been expressed many times. Their wish is that it should work without any extra efforts from the family members and that it should sort information so that it was delivered to the right person. Our shared understanding of their way of being as a family wanders along in the same direction as they have expressed. We can see that they really need a shared central for information, a shared structure for handling notes from school, time tables for hockey training and matches and coordination of events and people.

To understand how the Red family would use such a central in real life scenarios we had a joint workshop in early January 2003 with the family and the Accord project at SICS, Swedish Institute of Computer Science in Kista. The aim was to look at the whole chain of usage, to narrow down the over all wish for a central where everything can be organized to real use scenarios.

First, we split into two groups where all three generations were represented. The scenario making was divided into two steps. First, each group tried to find a real scenario form their common life, a scenario where every one of the family members had a role and could fit in. There should be some sort of communication difficulty involved. Second, each group tried to find a solution to the problem in the same scenario.

Scenario A

It is Marias birthday (the mother inRed nuclear family household) and she is going to invite family and some very close friends to a birthday dinner. She will invite everyone to a restaurant. That is why it is so important for her to get confirmation about how many that will come. Maria does not like calling everyone. That is not her way of doing things. It takes too much time, she thinks. If she writes ordinary invitation cards and send them via mail, it will take some time before she gets the confirmation from everyone, if they ever confirm. She knows her family. By that time it could be too late to order a table at the restaurant.

Solution to scenario A

So, she sits down at home at the kitchen table. She pulls out the keyboard from the surface on the table and starts typing. Then she finds some nice pictures on the table and arranges a nice card and finally gives her signature to it. She sends it to her family members. They get a nice invitation card on a display somewhere. But they can also read it as an SMS text message, an e-mail or a voice message. That is for the receiver to decide.

Scenario B

The whole family were going to visit grandma on the other side of town. But she got ill and wanted to cancel the visit. So, she calls home to her daughter's house. It is only one of the granddaughters, Sanna, at home. The otheras are away on a KTH workshop. They speak for a while and the granddaughter takes a message about her illness and the cancellation. Sanna then calles her father on his mobile phone to inform him. Then it is up to him to inform everyone else.

Solution to scenario B

Grandmother is not likely to use anything else but the telephone, so she calls the nuclear family household, speaks with her grand daughter Sanna about the cancellation. Sanna then sends an e-mail from the house central. She presses the buttons representing the persons she wants to send the message to. The central unit is set up by the family so that all new messages that concerned the same day is always sent by SMS to the people concerned.

They also made a sketch on how that central unit could look like and what features it could have.

Results

From the workshop, we extracted some important issues that are considered from a personal perspective, but with a focus on family coordination and communication.

– You want to make a message in the way you find the most convenient. Maria wants to type but sign it with a pen and Mats wants to speak messages, for example.

– In what format the receiver wants to receive the message is up to her or him. Linda wants messages as SMS's on the mobile phone, for example.

– In your home, you need a display for messages going to the household members in the house. Grandma can call the house and leave a message on the display for everyone to see.

Paper prototype

From the sketch of the scenario central and in relation to the real life scenarios, we made a small portable paper prototype that was sent out to all the family participants. The task was put down real messages that was or could have been delivered to any of the family members, and then to answer questions to each message.

"When you are writing/drawing the message underneath:
Where are you? What time is it?
When should this message be read, seen?
What feedback are you expecting?
In what way did you deliver this message for real?"

The aim of this prototype is to focus on real use from their lives. It is important to make their needs explicit, both concerning the structure of how things should be done and also concerning appearance.

After some weeks of prototype usage, we went to the households to tell them a little about the background of the prototype, (Hanna's and Sara's families use of the messageProbe, the constrained ink metaphor, Blue family door prototyping, (Deliverable 1.2 & 2.2) and the Red family activity on the workshop at SICS), but also to discuss it further. How should it be used, what features are important, what was good about it, what was bad, etc?

To collect the feedback from each message and to get a more complete picture of whole chain of activities around the specific message, we used a modification of the CARD technique (Muller, 2001) Different cards focus on different aspects of the messaging.

Time. When should the receiver read/see the message?
Activity. What activity is following the message?
Answer. What answer is the sender expecting to get?
In the head. What common information do the sender and the receiver have?

We also had a transparent card were the receiver wrote the actual answer to the message.

Prototype feedback from Green family

Lennart Green says: "I like it because it is small and portable". He compares it with a telephone, on which you have to press more buttons to do anything at all. On this, you can just write what you want with a pen and then press the button to the person to which the note should be sent. He makes connections between the prototype and a "palm". "According to size anyway, they feel the same, and that you can write on it. But the prototype is more personal for a smaller number of people that you know fairly well".

Lennart asks whether this prototype should be connected all the time. He answers himself by wanting it to be. The connection should be instant and simple. Lennart talks about "three party messages" and about drawing. It could be good to have when you make maps or something. He is referring to a golf trip with their friends and they want to get in contact with one another on their joint journey. Sometimes they go three couples to the same resort, but might go golfing on different courts or live in different hotels. Drawing, as well as writing, would facilitate their communication during these occasions. "The thing is that it is working on full graphics, isn't it?", he says.

Barbro is talking in general terms of feedback on send messages. Lennart says that he wants to know whether the receiver of the message really have received it, taken part of it and understood. There is a difference in those three "modes" of getting an understanding of how the message is received. Lennart is actually wondering what kind of feedback Barbro wants? She talks about buzz or beeps. She gives an example, from the prototype, where some sort of feedback would be necessary.

The 8/4 at 21.00 she wonders whether she is going to pick up the grandchildren from the day care centre the day after, or not? She needs an answer within 30 minutes, because she does not want to stay up any later. In real life, she made a phone call to her daughter Sara to check this. She thought it wouldn't be necessary to talk to Sara. Talking on the phone implies a little bit more than the mere info about the picking up of children. With the prototype she could just write the message and it would be seen remotely. She would just need a buzz to know that someone had seen her question and then answer it.

Barbro thinks the telephone is a bit "pretentious". It requires our attention to it and she have to deal with it in a certain way. Barbro and Lennart start talking about how they have different approaches to telephones and telephone messages. They have told us before that Lennart can answer the phone in the middle of dinner just to hear who it is and then reply that he will phone back later. While Barbro can not answer the phone because she finds it difficult to say that the person calling is actually interrupting something. Instead, Barbro does not answer. Lennart says he is much too curious to do that. Then he tells us the story of Barbro calling her own answering machine to remind her of something when she gets home. Lennart suggests that the message on the inkpad could be time related, so Barbro can make her message to be seen for two hours until she gets home. Barbro thinks she needs to be reminded until she has actually done what she has to do.

Jonas, Lennart's and Barbro's son in law comments that the prototype in its present appearance is related to the family participants of the project, not to his closest family and friends. During the prototyping period, he called his mother and his brothers, which are perhaps more closely related to him, but that was never written down in the prototype.

Questions and dialogue to make design decisions

Reading about the families above, you can see that there is a certain way in which the family members themselves, together in groups or pairs, discuss the features of the prototype and what it can or should do for them. They ask themselves questions and they tell stories of situations when the prototype could be handy. They also ask questions to each other to get another persons view of the story. This helps us undertand how they percieve the artefacts and thir context. That hels us define the design space.

Technology struggle for prototype work

Within the interLiving project we have been contacted different providers of Internet access and broadband as customers, to make it possible for our families to use the applications for communication we have built together . This turned out to be extremely time consuming, complicated, stressful and filled with conflicts. Our experiences witness of a variety of ways that these companies treat their customers.

From contract to broadband "up running", the time span could be several months. Then, if a project household moved, the whole process started all over again. If we would be the one taking the invoice for the broadband to these families, this added to the difficulty for these companies to handle the administrative issues.

It has been a very instructive experience for us as a project to be in this "customer situation" not being able to have control over the time-span for the broadband access or support. We have managed to get personal contacts in some companies, BoStream for example, with people who have taken interest in our situation and helped us to navigate through the complex systems that our demands could be addressed.

Prototyping in the archipelago

One example of our struggle was to get broadband running in the archipelago. Blue family moves to an island in the archipelago in Stockholm during summer. This summer Matthias, the fifteen-year old teenager, did not want to come along and he was promised to stay at home by himself in the house in the southern part of Stockholm. This situation opened for a desire to have one of the prototypes installed at the summerhouse on the island to be able to communicate through writing and drawing to each other (eg. between the summer house and the winter house).

We started to investigate this possibility. Net access was the problem. This, we were told by people working with this kind of matters, could be solved with a radio link using the pilot radio tower for setting up an antenna. But for that, we needed an agreement with the lawyer from the company who owned the radio tower to add some equipment to it. We were told many times that this could be solved alongside the work being done and we were told many times different-dates when it all should be up running. We therefore installed the equipment at the summerhouse.

At the beginning, we had good hopes that all the problems could be solved-but as the weeks passed, we decided to try another path. This time the option-seemed to be ADSL since this had become an opportunity that did not exist when we first started to investigate the possible ways for net access to the island. Now we had to purchase some more items to make the ADSL connection possi-ble. When we had gone through the process of negotiating time schedule for the connection we were in late August and the teenagers were back at school and we had to bring back the equipment to use between the two households in Stockholm instead.

Blue prototype work

Blue nuclear family, or rather the parents in Blue nuclear family, have had problems with family calendars, notes about school and sports events, organizing the right child to go to the right dentist at the right time, for example. With those problems in mind, we have done paper prototyping work in different ways to narrow down to real situations and how they would solve those situations (Deliveralbe1.2 & 2.2).

One big issue for the Blue nuclear family is reminding and remembering. For example, grandma Marianne called to the Blue nuclear household to ask for Matthias', the fifteen-year old grandson, size of his head. She was going to knit him a ski cap, on his request. She did not get hold of him but spoke with his brother Emil who was asked to tell Matthias to call back. But he didn't. Then Marianne called again and spoke with Eva, the mother. She said she would tell Matthias to call, but nothing happened. So, now Marianne will simply knit in ladies size and hope it will fit.

Prototype installation

Though some broad band technology difficulties, we have installed the electronic version of the inkPad prototype. The electronic inkPad is a distributed shared surface that you can draw on with time-constrained ink. It consists of a Wacom screen and a pen, run on a Mac cube. What we wanted to investigate in the prototype was how the user wants to give time to the ink. Is it exact time? Is it relative time? What tools would be needed? What should they look like? How should they work?

Looking at the example above with Marianne question to Matthias, she could write it with no time constraints to the ink. She would instead want an answer. When she had received the answer, she could just dump the question in the waste bin.

In the case with the sons going to the dentists, the information is written to the inkPad any day, but the information should be extremely visible the very same day for the appointment.

Eva definitely wanted a calendar on the same shared surface. Otherwise, she would need to sit with her calendar beside the screen when she is writing a message anyway. She also pointed out to us that if the shared surface should be on all the time, the Wacom screen could work in a kitchen or in the living room, but definitely not in a bedroom. According to Eva, the screen's light was so strong that when she was out with the dog early in the morning, the whole empty, normally dark, kitchen looked like an aquarium! You would not want that running in your bedroom. That gives the idea to have the screen running continuously for messages to be seen at certain times but also to have the possibility to have the screen dark when nothing happens.

Below we show some design aspects to the personal inkPad and the house inkPad suggested by the family members. It is important that the personal inkpad has pocket size. That personal inkPad should be connected to other family member inkPads and also to a central unit inkPad (familyNet) in your house. Perhaps it should be possible to personalize it with sound or buzz for feedback on sent messages, so you know that the receiver have seen the message. To be able to write and draw with a pen is important.

To write with keyboard at home central inkPad is important. Time constraints on the notes you are making is important, especially when the note is sent to the house and not to a person. It is important to have the screen running continuously so that you can see when a time-constrained message is showing. But there should be possible to shut down the screen when nothing is happening.

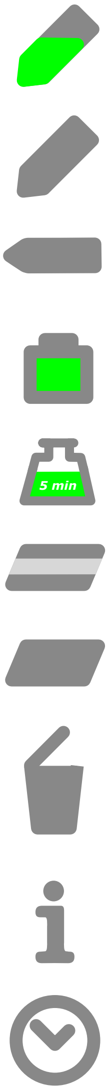


Figure 5. Early symbols for the InkPad interface.

InkPad

The basic ideas of the InkPad are that you draw on it and these drawings are constrained by time. What is drawn is instantly shown on displays in the remote households. Therefore it is important that we do not only make the affordance to draw visible since the most interesting aspects are the distribution and the different properties that the ink can have.

We plan to visualize the communications aspects by representing the other locations or people that can see what is happening in some way. In the future when we will have mobile personal units as well this must be dealt with. There are many solutions for this in related systems that seem to work fairly well, for example in instant messaging systems and video conferencing systems run on the Internet.

Ink Factory

The other aspect is the disappearing and the appearing ink is not so easy to visualize since this is not a feature that anybody would expect. These features are not at all difficult to understand once you discover them and they make people very interested. So the difficulty lies partly in making people discover them. But also in setting the constraints.

We have done several different tests with alternative interfaces and representations of the ink constraints. Some are shown in figs 5-9.

We do not want the setting of the ink properties to look too much like a palette thus making people think of a drawing application as discussed above. The aspect we want to focus on are the setting of the time, and possibly addressing although we think that that is better done outside the of the Ink properties. But the notion of private ink is easy to grasp, as an example where it could be convenient to have the distribution aspects inherent in the ink properties.

Touch or pen operated screen/display

We have to consider the use of a touch or pen operated screen like on the more expensive new mobile phones and PDAs. This is different from a mouse-operated

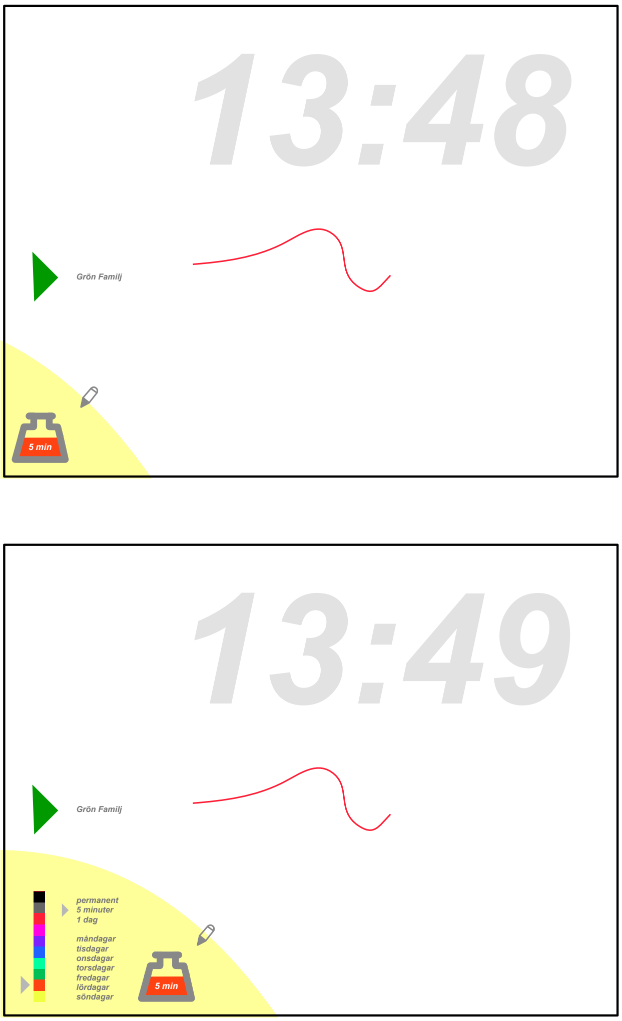


Figure 6. Ideas for solution of a ink factory. A drawer slides onto the screen.

interaction because they do not afford a "click" or "mouse down". You only have location, tap and move of course.

Size of display

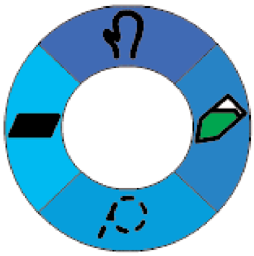
So far we are using a "normal" screen size (1024x768). But when we implement on smaller screens like 320x208, we have to consider pan, zoom, list or some other presentation, representation of the drawings.

Clutter

One problem with drawings being invisible is that it is possible to draw "on top" of them. And thus getting a clutter of notes on top of each other making it hard or difficult to understand them. The solutions here could involve some kind of listing and grouping which should be developed together with constraints with small screen sizes.

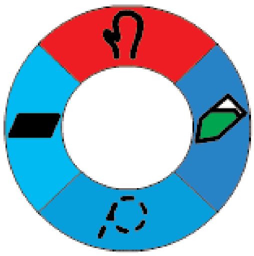
Pie or marking menus vs. symbols/icons always available on the screen

We have had basically three different overall approaches to the interaction. They are:
- all symbols always visible on the screen
- some of these placed in “drawers” so they can be visible or not, and
pie menus where nothing is visible on screen until you hold the pointer still for a while. Then several different possibilities are shown that you can choose from by moving the cursor in different directions. This can be followed by several different menus to facilitate complex choices.



Timeline/calendar – both for checking and setting

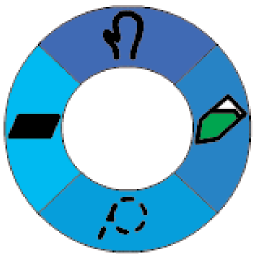
Some people have discussed the need to be able to set reminders by date, like appointments with a teacher or the children’s dentist. You also need to be able set reoccurring events like handball practice every Monday. To do this conveniently you probably need to have a calendar visible. We have also discussed an info-tool that can help you see what notes will appear in the future.



Pen – “pick up” and “lay down”

A consequence of a touch or pen operated display is that they do not afford mouse clicks. That means that if you have an icon representing the pen you have trouble because you will both want to move the pen to the location where you want to draw and then draw. One of the solutions that we explored was to have pens (at times we have had several pens with different properties at the same time) lying down when they did not make lines. Tapping on them made them rise in a 45° angle and when moved they draw lines. Tapping again makes them lie down.

This approach is currently abandoned and we do not have any pen representation on screen since we use a real pen (Wacom Cintiq).



Figures 7-9. Screen dumps from experiments with alternative ways of setting the time.

Deleting, erasing

Currently dragging lines to the trash deletes them. It is also possible to drag the trashcan symbol to the lines and that way deleting them. The Wacom pen affords “erasing” if you rub with the back of the pen but this is not yet implemented.

WYSIWIS or not?

“What You See Is What I See” (WYSIWIS) is a simple and probably a good approach that we are currently pursuing. But by affording grouping of lines into single drawings facilitates the possibility to have personalized views. You could then arrange the drawings according to your own strategy. This will be even more interesting and important on small screens.

Address person or location

From workshops and other discussions it seems obvious that people should be able to have drawings sent to different people and/or locations. This could be controlled through FamilyNet or within InkPad. Most of these aspects are discussed thoroughly in the FamilyNet papers.

In scenarios we have had examples where it would be attractive to be able to have a message appear at a specific location when a certain person arrives there. This calls for rather complicated set up of the ink properties as well as recognition at the remote location.

Status or who is seeing what I draw now?
A consequence of the addressing feature is the need to have a visual representation of where the current drawing is visible.

Context

Analyzing where the family members decided to locate both the messageBoard (D 1.2) and the InkPad we identified two rather different strategies or choices. The first approach was to have them in a central place where they were easily visible most of the day when people were at home. This is a rather utilitarian approach and most often involved either moving something else away or squeezing the probe between other stuff. The other households decided to put them in a more remote location, like a bedroom. This way it would not interfere with the way that they wanted their household to be perceived.

Most of the households placed the technology centrally. One example of this is seen on figure 10. The discussion around this involves similarities with other technical artefact that you choose to have visible in your house, like toasters, television sets, stoves, refrigerators, etc. As a designer you may not think that these artefacts fit into the environment. They have different character and all that. The family members also think that the stuff is ugly when specifically asked, but regarding the whole context it is naturally meaningful for the family members to have these artefacts.

One woman said that it looked like they were living in an aquarium When the display is on in the evening

Future directions and Discussion

We have learned a great deal about the different individuals lives from all the different activities we have done together, (Mackay. 1997). It is clear that different users acquire different meanings from the same artefact. This seems to be

Figure 10. One of the contexts where the InkPad was installed.

emphasized more in domestic environments and family settings than in work places.

We are discussing how and how much the people should be able to adapt the technology for their purposes. It seems that the less constraints there are the more room for personal strategies to evolve. These are clearly the results form our different low-tech paper prototypes that the family members have used. They develop conventions that have meaning for them.

The blank interface affords the user to use it in any way that seems meaningful. There is no predefined path of activity that must be followed.

Even though our intention is the InkPad to be on constantly, we realise that there might be a power failure or some family member would want to move the probe to another location. After connecting the power cord into an outlet the prototype is shortly ready to use. There is no need to "manually start" any application, remember passwords or perform similar operations that would have signified a normal computer.

We plan to test and use the InkPad on mobile phones and or PDAs. Then we would learn more about what needs and desires it could fulfil. One aspect that seems clear already is that then there would be more use for "private ink", ... This would of course require that we develop the pan, zoom, list aspects discussed above.

NOTES

We gratefully thank our family design partners for their contributions. The names of the family members are not their real and we are glad to have everybody's permission to publish the research. We would also like to thank BoStream for their support, http://www.bostream.com

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Shared Family Calendars: Promoting Symmetry and Accessibility

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ABSTRACT
We describe the design and use of a system facilitating the sharing of calendar information between remotely located family members. Users can choose to enter information into a computerized calendar or to write by hand on digital paper calendars. All of the information is automatically shared among everyone in the distributed family.

KEYWORDS
Home, Calendar, digital paper, elderly, universal usability, family technology, privacy.

1. INTRODUCTION

There is increased interest in the development of new technologies for the home and for families.Previous research revealed the importance of respecting privacy, not creating new obligations, and offering multiple modes of communication. This project focused on facilitating coordination and awareness between distributed family members by the sharing of calendar information. In particular, it addresses the needs of older adults for simple modes of interaction and promotes a symmetrical open exchange of information between family members. Our experience leads us to believe that sharing of calendar information provides a useful window into the day-to-day activities of remote family members. Grown children can see if their parents' activity level is normal or not and grandparents greatly appreciate the heightened sense of awareness of their children and grandchildren's daily lives. While we acknowledge that no single tool will suit the needs of every family, we believe that the prototypes we have developed can lead to successful products that would serve the needs of distributed families wishing to remain in touch.

This paper first describes the context and motivation for the design of shared family calendars, and then reviews previous work on shared calendars and on technologies for sharing information between families. A prototype for shared family calendars using digital paper is described and results of a field study of the use of the prototype in three households are presented. We conclude with suggestions for improvements and possible future directions.

2. CONTEXT AND MOTIVATION

Our work is part of the interLiving project, a 3 year, European Union-funded project where we work with distributed, multi-generational families as design partners to create new technologies. Using cultural and design probes, interviews and workshops, the interLiving project identified coordination and awareness as important needs of families. In parallel, a web survey confirmed the need for coordination between the many calendars users maintain. Finally, we studied the needs of one extended family in more detail and they helped us design and test the prototype.

2.1 The interLiving project

The interLiving project recruited 3 families in Sweden, 3 in France, and 1 in the U.S. Each family has multiple households and generations. We began with an ethnographic approach, interviewing the families in their homes to learn about their needs for and attitudes toward technology. Next, we appropriated the idea of cultural probes (Gaver and Pacenti, 1999) from design researchers, giving the families tools such as disposable cameras, diaries, and Post-It notes to gather information about their daily lives and communication habits. As cultural probes, these artifacts were meant to provide researchers with insight about the families and to inspire new design ideas.

After gathering information about the families and having them become more comfortable with the project, our goal was to help them become our partners in the design of new technologies. Participatory design with families had not been tried before, so another goal was to learn, sometimes on the fly, how to adapt existing techniques and invent new ones that would work with multi-generational families. We conducted workshops with individual households, entire families, and multiple families using low-tech prototyping exercises to get the families comfortable with the idea of designing things. We discovered that family dynamics plays an important role in these workshops, and we learned that occasionally separating families by gender or age was effective in allowing everyone's voice to be heard.

One of our key challenges was to develop new participatory design strategies in which family members could actively participate in the design of new technology. We did not expect the family members to become designers, but we did want them to be active in the design process. To achieve this goal, we introduced the concept of a 'technology probe' (Hutchinson et al. 2003), which combines the social science goal of collecting data about the use of the technology in a real-world setting, the engineering goal of field testing the technology, and the design goal of inspiring users (and designers) to think of new kinds of technology.

Our version of technology probes involved installing a technology into the families' homes and watching them use it over a period of time. We instrumented our technology probes to capture two types of data: the use of the probe itself and the relationships within the family. We developed and installed two technology probes: the MessageProbe and the VideoProbe. Each was designed to gather data about a family's communication patterns while inspiring them to think about new ways of communicating.

The MessageProbe was a simple application that enabled members of a distributed family to communicate using digital Post-It notes. It functioned synchronously, with two or more family members writing from different locations at the same time, or asynchronously, with family members checking it periodically for new messages. The probes were connected only to a small set of family members, removing the need for complicated setup and remembering names or addresses. There was no need to use the mouse or keyboard – just a writable LCD tablet and pen (Fig. 1). The MessageProbe was deployed in the three households of our U.S. family design partners and in two households of our Swedish family design. In the U.S, the probes were used mostly to write notes updating status, news, feelings, and coordination. The probe helped reveal that coordination between the households was an important issue. In contrast to the U.S. family, the Swedish messages were more playful, used mostly by two sisters to write fun notes to each other.

Figure 1: The MessageProbe in use in the homes of our U.S. family

The VideoProbe provided a simple method of sharing impromptu images among family members living in different households. We used a video camera that takes a snapshot when the image it captures becomes steady for approximately three seconds. The images were collected, stored, and made available to anyone else in the network. Family members could browse the images with a remote control. Images faded over time and eventually disappeared, to encourage families to create new ones. The VideoProbe was deployed in four households of two of our French family design partners – two sisters from one family and two brothers from another family. Like the MessageProbe, the families used it in a playful way, to send funny pictures, and for communication and coordination purposes - e.g. taking a picture of a hand-written message.

The probes were successful as concrete applications that the families could use as a point of comparison for how their needs as co-located and distributed family members were or were not being met by current technologies. One of the most prominent needs we identified among these families across all cultures and ages, through our interviews, workshops and the technology probe deployments, was coordinating between and within households.

Families need to coordinate everything from who picks children up from school and where to meet after work, to scheduling surprise parties or vacations. The dizzying array of technologies available to families to accomplish these tasks, from cell phones and PDAs to Internet calendars, seems only to have added to the existing confusion of paper calendars, Post-It notes, and answering machines. Frequently, problems arise because the necessary information isn't available in the right place or at the right time – a PDA isn't synchronized with the home calendar and someone misses an appointment, the soccer schedule is at home when the coordinating parent is at work, or the cell phone of the person that is picking someone up is turned off or out of power.

To explore these issues more thoroughly, we held more workshops with our family design partners to brainstorm about coordination needs. Across all three cultures, we saw a common desire for better ways of keeping track of the multiple people and events going on between and within the various family households (Figs. 2, 3 and 4). Whether it was a display of multiple people's calendars embedded in the refrigerator or a small piece of jewelry that pinched or blew air as a reminder or message, our design partners were full of creative and practical ideas for improving family coordination. We saw a continuum of devices, from unobtrusive things to support lightweight awareness, all the way to full-blown calendaring solutions accessible from cell phones, PDAs, refrigerators, and watches. People's needs were located along this continuum depending on the closeness of their relationships and their practical needs for coordination. Relying on someone to pick up your children might require close coordination, while letting your significant other know you are thinking about them might just require a small bit of awareness.

Figure 3: Augmented awareness prototypes designed during the family workshops: a bracelet that shines (left) and a phone that blows air (right) to indicates that another family member may think of you or alert you a something.

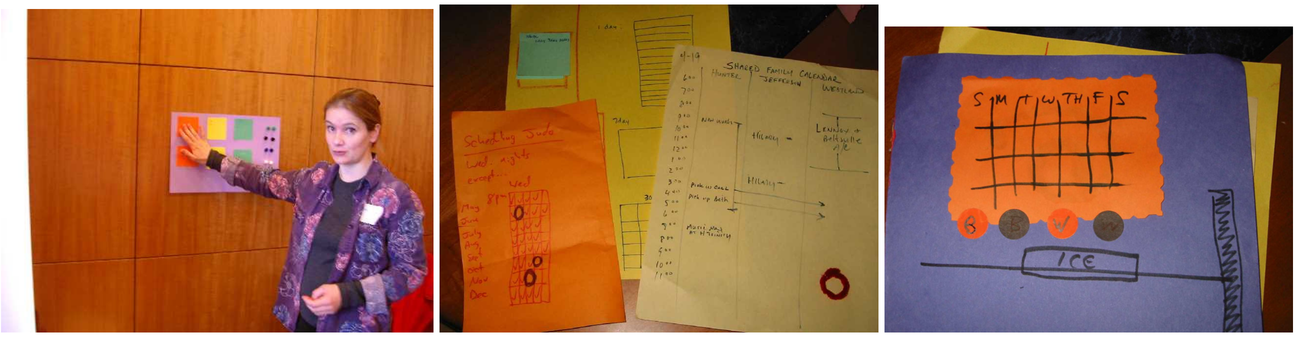


Figure 4: Shared calendar prototypes designed during the family workshops: for the wall (left), or the refrigerator (middle and right)

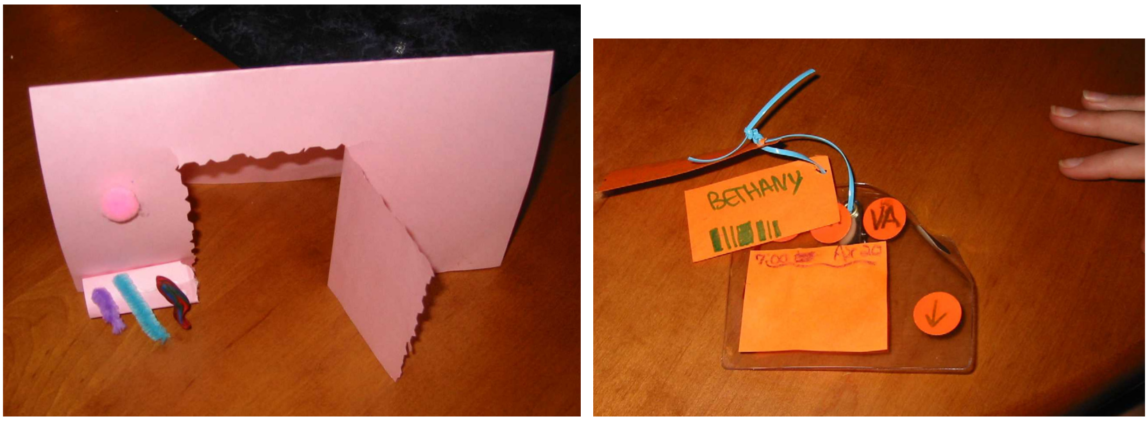


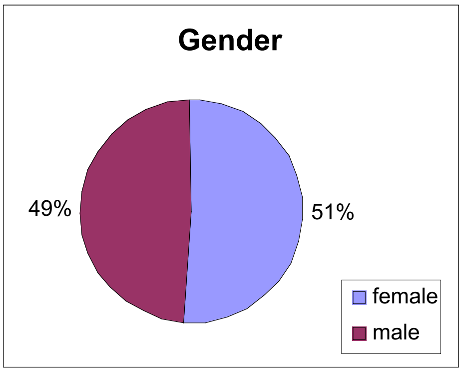
Figure 5: Other opportunities for sharing just-in-time information: a door messenger prototype allows family members to record audio messages saying where they are going as they leave the house (left), mobile devices for children send discrete updates about whereabouts (right).

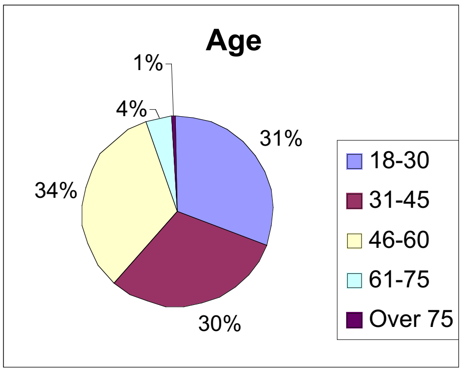
2.2 Web survey

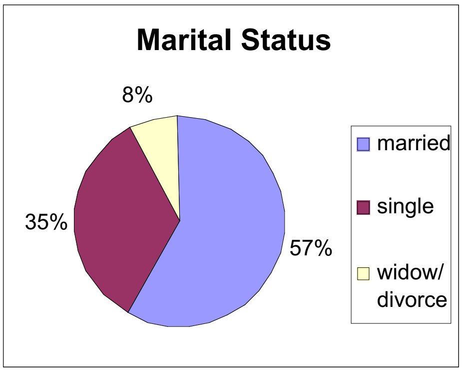
The early paper prototypes designed during the family workshops were helpful in eliciting ideas about how and why existing calendaring events might be shared electronically, and how they might be used for coordination activities like arranging rides for children. To augment our findings, we designed a survey (Hutchinson et al., 2002), available at https://www.cs.umd.edu/users/hilary/survey/survey.htm) to gather more information about not only how people currently do their calendaring (what they record, who they share with, etc.) but also how they handle uncertain or fuzzy calendar information. We sent it to our friends, family members, and colleagues with a request for them to forward it on to their friends and colleagues. We realized that this "chain mail" approach would probably yield responses from a population biased towards people demographically similar to ourselves – upper middle class and technologically savvy – but we knew that this would be the initial target audience for our application.

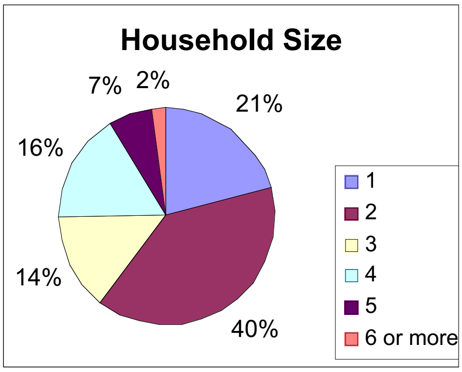
Over a period of about 2 months (end of July to beginning of September, 2002), we received over 400 responses to the survey. We don't really know what percentage of recipients this represents because of the chain-mail format of the survey, but consider this response to be quite good. We are aware that some of our results may be biased because individuals from the same family responded to the survey. Their individual calendaring habits, preferences, and problems are distinct, but their family calendaring issues (e.g. who maintains the family calendar) are probably similar. Many of our respondents likely came from the HCI community as the mailing went out to our large lab mailing list. Still, we gathered much valuable information.

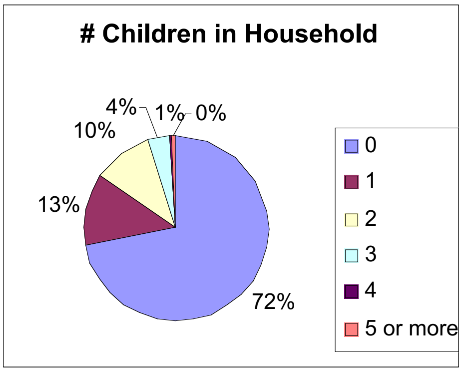
Demographics: Out of 401 respondents, we had near parity between men and women (49% vs. 51%). By age, we had about 30% each between 18 and 30, 31 and 45, and 46 and 60, but only 5% over 60. Fortunately, we have some of family design partners are grandparents, so we do have representation of the needs of this demographic. More than half of the respondents (57%) were married, while about a third (35%) were single, and the remainder widowed or divorced. 60% of the respondents lived in households with more than one person, but only 28% had children living with them. We would have liked to have had more respondents with children, since we believe that they add numerous scheduling issues due to their many activities, and their need for adult supervision and transportation. However, our family design partners include children, so we do cover this demographic that way. Finally, as expected, the bulk of respondents (70%) use a computer at least 30 hours a week.

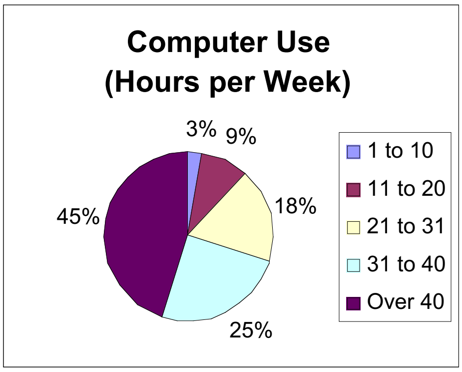






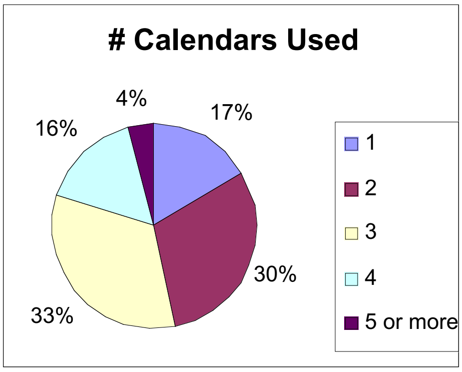


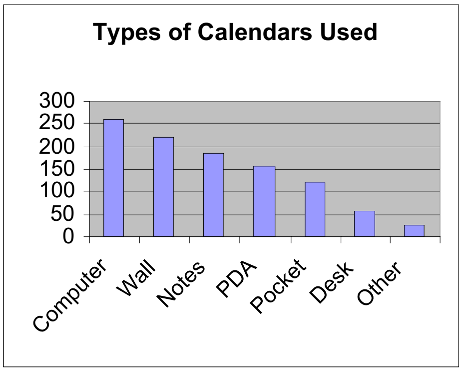


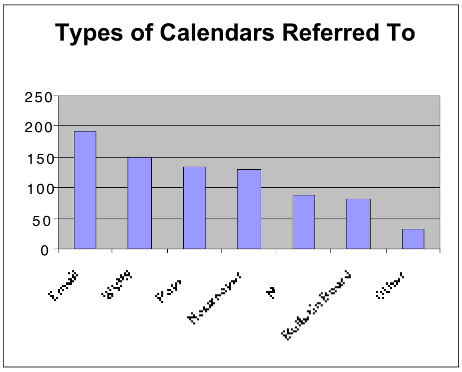


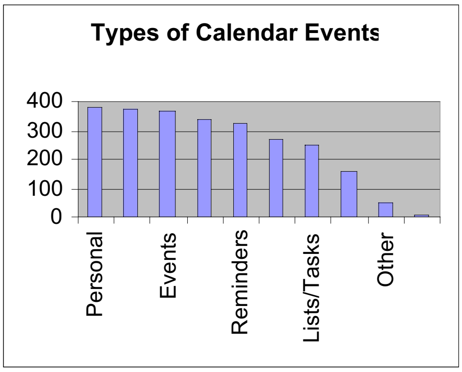
Calendar Usage

Only 17% of respondents use just one calendar to record information. Given the heavy percentage of computer users, it is not surprising that many people use computers and PDAs for recording and gathering information, but paper-based calendars are also heavily utilized. Personal and work appointments and events are the most recorded items.

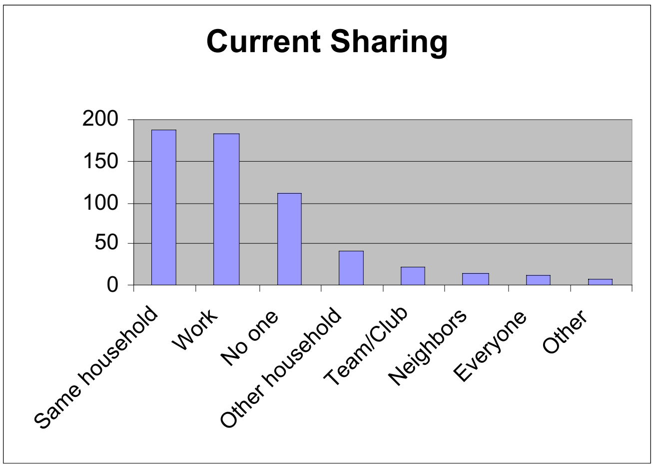


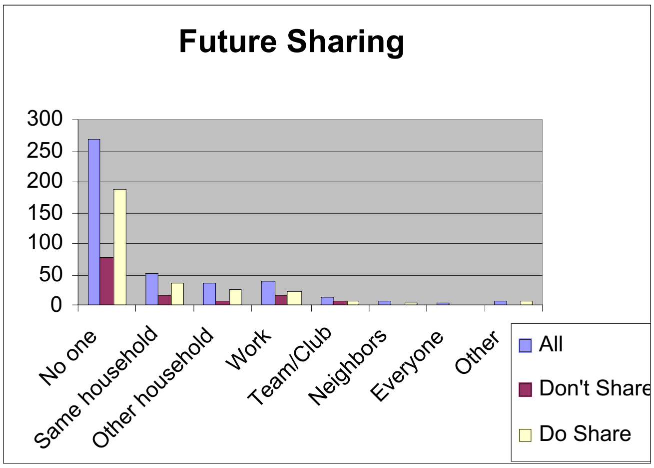






Calendar Sharing: The majority of calendar sharing takes place between people in the same household, or with work colleagues. These are also the people that respondents most wanted to share with in the future.





Calendar Problems: The following were the most common problems cited (at least 20 people mentioned them), in order from most to least frequent:

- Too many calendars to maintain, synchronize, and/or duplicate information on
- Unable to access from a different location
- Paper or electronic spaces too small to write in
- Compatibility issues with other software

Uncertain Events: The following were the most common ways of handling uncertain or tentative events (at least 50 people mentioned them), in order from most to least frequent:

- To do lists/notes/Post-It notes
- Make item visually distinct, using a question mark, pencil, or different color/font
- Guess day/time and manually or automatically move as necessary

At least 20 people also mentioned the following:

- Don't record it
- Record it somewhere else on the calendar, like a margin, evening, or Sunday
- Mark it with a tentative, free, or low priority label
- Set a reminder or alarm

Synchronization and Duplication: Out of 318 people who answered the question, only 53 reported they explicitly do not synchronize or duplicate information between calendars.

Maintenance of Family Calendar Information: Of the 270 people with at least 2 members in their household who answered this question:

- 119 have a single person who mostly maintains the family calendar information
- 151 have more than one person do this
- More than 90% of the "single maintainers" were women

3. THE CASE OF OUR FAMILY DESIGN PARTNER

The U.S. family worked more closely with us on this prototype while other families worked with our European partners on other prototypes. The U.S. family had already worked on the MessageProbe with us so we first present that family and then summarize the results of the MessageProbe testing relevant to the shared calendar prototype design. Next we summarize the interviews conducted in the family regarding their calendaring habits and their feedback to early paper prototypes of the shared calendars.

3.1 The family

The family consists of three households. The junior family consists of two parents and two children between the age of 10 and 13. Both parents work and the children have a very busy schedule of school and non-school activities including early morning swim practice, music lessons, theater or dance practice, rehearsals and concerts, interspersed with occasional school-related events such as fund-raising or test preparation, as well as medical appointments and social activities. The parents also organize car-pooling to school and volunteer to help in many of their children activities.

The two sets of grandparents constitute the other two households. Both live close to the junior family. They are in regular contact by telephone with their children (almost daily) and visit often. The paternal grandparents lived about 10 minutes away from the junior family but moved during the project to be within walking distance of their son's house. They had never used or owned a computer until we installed the MessageProbe in their house. With time they became more comfortable with the computer and bought their own (with the help of their son). Even though she was the most reluctant to use the computer and participate in this experiment at its beginning, the main user is the grandmother. She enjoys playing solitaire and can use the basic functions of AOL email to communicate with friends. The grandfather uses the Internet to check the stock market every day. However, using the computer remains a formidable challenge that can not be sustained without regular assistance from family members or friends. They can perform a few simple tasks using “recipes” provided by others, but any unexpected behavior of the computer results in great confusion, sometimes a request for help, but usually abandonment. The computer is appreciated when working properly but rapidly ignored when something goes wrong.

The maternal grandparents live about 15 minutes away from their daughter’s house. They have had their own computer for many years. The grandfather is fairly comfortable with computer technology, having used them regularly for work before retirement. He is a regular email user, and can comfortably help us “debug” problems over the phone when they occur. He has a strong - but often well founded- skepticism about computer technology and its reliability. The grandmother has not shown too much interest in using the computer herself, but has been supportive of the experiment and mostly an indirect user of the information provided by the computer.

3.2 Lessons learned from the family during the early use of the MessageProbe

The family used the MessageProbe for a few weeks during an earlier phase of the interLiving project. Three relevant results came from this experience: 1) the desire to have more awareness between remote households, 2) the desire to improve the coordinating of events such as arranging childcare arrangements or choosing a time to visit, and 3) the desire to have more reliable hardware and software. The first issue confirmed that the CSCW literature advocating the support of remote awareness in workplace groupware applications carries over to families as well. Despite the fact that the MessageProbe interface was designed to be used both asynchronously and synchronously, users in all the households wrote a number of notes wondering if another party was “there” to chat, and used the board to play synchronous games like tic-tac-toe or connect the dots (Fig. 5).

This need for awareness carried over to the second issue of trying to coordinate between the different households. Our family partners tried to use the board to coordinate meetings and pickups for childcare. They found this task difficult because often the requestor wasn’t sure of the other party’s schedule and if they would even see the note in time. We realized that remote schedule access would be helpful to address this problem. Knowing what others were doing at the time you needed them to pick up a child might save you the trouble of writing a message, and knowing what they were doing at the time you wrote the message would be helpful in deciding if they would even see the message before you needed their help.

The most obvious lesson from that experiment was the need for more reliable technology. We provided the households with high-speed Internet access, but it frequently didn’t work for various reasons. The Internet service sometimes failed and the MessageProbe software or the server at Maryland supporting it sometimes crashed. When the software crashed, the less technology-savvy households often had to rely on the more savvy relatives to help them, adding an extra burden to these relatives. In another case, a family went away and when they came back, had forgotten how to use the interface. This result really drove home the already-reported-on need to make technologies for the home more attractive, easy to use, and fault-tolerant than the ugly, often complicated and crash-prone technology we tolerate at work. The families all agreed that the software was fun to play with, but they couldn’t rely on it for any kind of important communications – if a child needed to be picked up from school, they would use the phone. Since they could use it for unimportant communication, this family didn’t show much interest in continuing to use the probe.

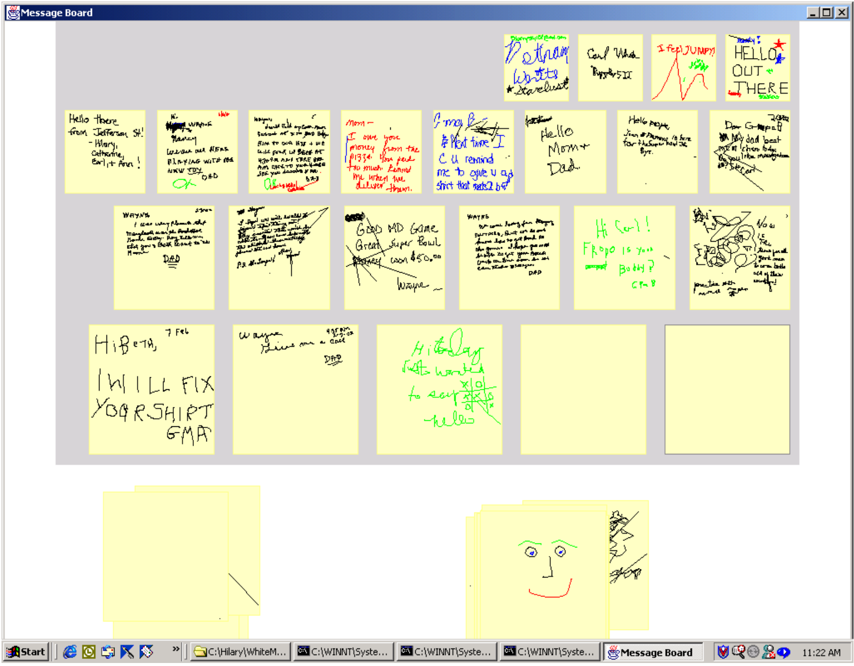


Fig. 5: Example of messages written on the message board by the family.

3.3 Interviews about calendar information

After we took the decision to pursue the design of shared calendars as our next step, we conducted a new round of interviews in the three households aimed at understanding how calendar information was kept and communicated between family members. After the first interviews we sketched paper mockups (Fig. 6) of a shared calendar and collected feedback and suggestions from the families.

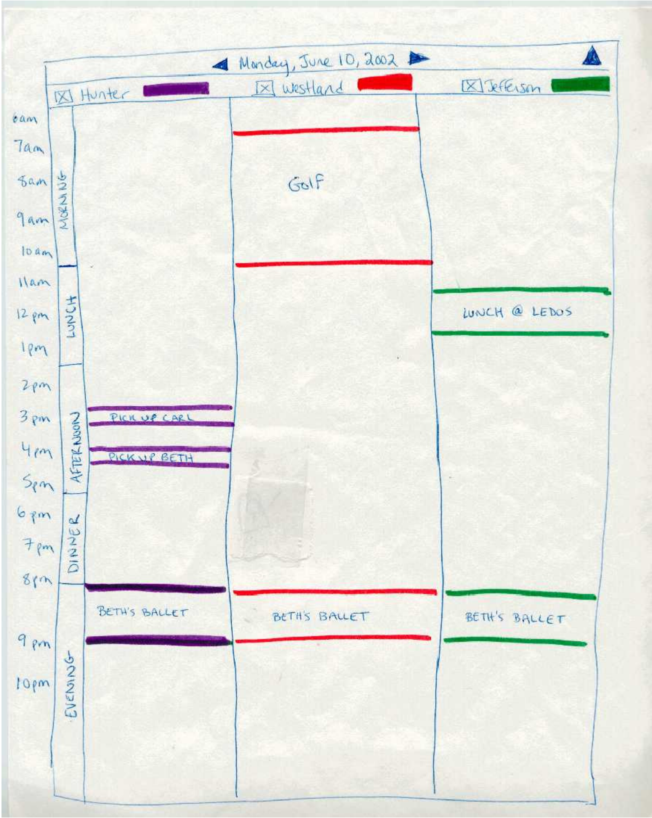


Fig. 6: Early paper mockup showing the three shared calendars for the three household, populated with realistic examples, used to collect early feedback on our planned prototype.

The busy calendar of the junior family is managed using a computer setup in the most used room in the house: the large kitchen where most meals are taken (Fig. 7). For more than a year before we started working with them, the junior family has been using Microsoft Outlook calendar program to record appointments and set reminders for the family. The parents usually enter events in the calendar but all four members of the family know how to consult the calendar, which they do several times a day. They are pretty happy with the system, but don't have a way of checking or managing the calendar when they are outside of the house. For this household, a shared electronic calendar would thus be an easy transition, but they would also benefit from some portable devices.

In looking at the paper prototype, they thought it would be nice to be able to put events on someone else's calendar, so long as it was clear whom they were coming from and it didn't imply any kind of commitment on the recipient's part. They liked the idea of keeping the grandparents in the loop with what was going on in their house, especially since grandparents can sometimes be a bit forgetful. We discussed the different ways you could use the calendar: to enter traditional precisely timed events (e.g. dentist at 9am") or for fuzzy events (e.g. "shopping today"), reminders, tasks/to-do lists, and notifications. We discussed how most of those things could be done in Outlook, but not always very easily. For example in Outlook, tasks are separated from calendar entries, and fuzzy times are hard to show. Notifiers (e.g. I've gone to the gym) could be done with separate electronic "sticky" notes but all those things are complex to specify and are not well integrated. All agreed that it would be too difficult to use for most of the grandparents.

We discussed the issue of data input because keyboards (or the tablet used with the MessageProbe) were hard for the grandparents to use. Voice annotations seemed like a great idea for notifications and sharing requests. If you wanted to put an event on someone else's calendar, you could drag it over to their column and then add a voice annotation that they could play. Or, if you were going out to do errands and wanted others to know where you were, you could just leave a voice annotation at the time you left. The audio quality would have to be quite good though. Interestingly, they have a microwave where you can record voice messages but no one uses it. So, we may to investigate if this feature would be useful.

Fig 7: The Junior family's daughter using the computer in a corner of the large kitchen. On that computer the Outlook calendar is updated and checked several times a day.

The two sets of grandparents rely entirely on paper for their calendar information. The paternal grandparents use a pocket calendar, maintained and used daily by the grandfather who meticulously records appointments but also keeps detailed diary information such as stock values or time spent on particular tasks (Fig. 8). The grandmother relies on the calendar kept by her husband, but also keeps a separate personal list of birthdays and other special regular events.

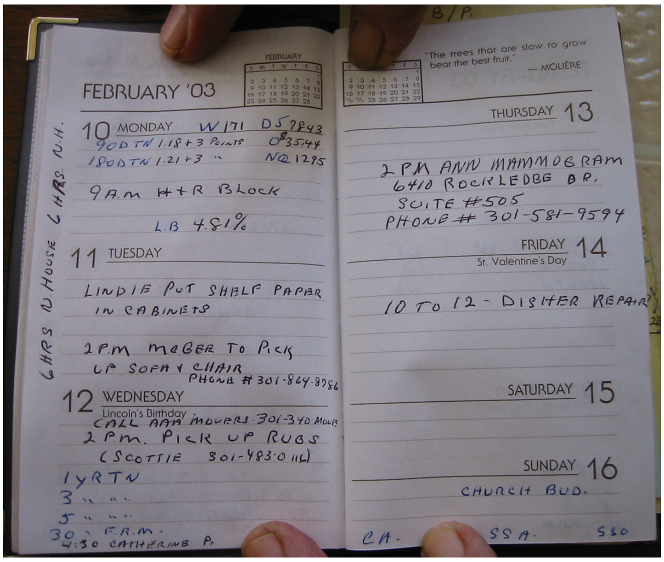


Fig. 8: The meticulously kept pocket calendar-diary of one of the grandfathers. A few appointments are recorded, plus several diary entries such a stock prices or hours worked on particular tasks.

The maternal grandparents have a much simpler, more ad-hoc way of handling calendaring. The grandmother handles most of it – important appointments or events (e.g. doctor's appointments) that come in paper format are put on the refrigerator as notes. To keep track of birthdays, she writes them on

3x5 note cards so they don't have to be entered into a calendar every year. A lot of their appointments are regular events (e.g. golf and haircuts) so they don't bother to write them down. A monthly wall calendar is used to record a very small number of special events. Occasionally messages are left on the coffee machine as special reminders (e.g. I'll go for lunch with Tom today after golf).

Our interviews of our family partners confirmed that even closely knit families who stay in touch through regular visits and phone conversations still have difficulties remembering the dates of each others' activities (e.g. Tell me again, when are you going on that trip to New York? Are the children still taking music lessons? Is school out for Veterans Day and do you need help from us that day?)

The grandparents know that their children and grandchildren's lives are very busy, so they clearly indicated that having access to their schedules would be nice. In looking at the early paper prototypes (Fig. 6) the idea of using voice for some features (e.g. I'm going to the store) came up. They wanted the calendar to flash or beep for reminders and messages. They liked the idea that if their children wanted to have them pick up one of the kids, they could drag that item from the children's calendar over to a grandparent calendar, and it would flash or beep until they saw it. They could accept the responsibility by clicking on it, or say no by dragging it back to their son's calendar. Given that they don't make much effort in their current calendaring, a simple, easily accessible interface was important. Writing on the refrigerator or paper was OK; typing appointments into a computer was not.

4 RELATED WORK

Coordination

Beginning with its first organized conference in 1986, the field of computer-supported cooperative design (CSCW) has produced a broad body of literature about how to design software (often called groupware) to support the work of groups of both collocated and distributed people (Ellis, C., Gibbs, S., & Rein, G., 1991; Grudin, J., 1994; Olson, G. & Olson, J., 1997.) There has been a great deal of research in the area of coordination technology, particularly group calendaring, but it is focused almost exclusively on the workplace (Beard, D. & Palanlappan, M., 1990; Palen, L., 1999; Bullen, C. & Bennett, J., 1990; Kelley, J. & Chapanis, A., 1982; Kincaid, C. & DuPont, P.; 1985; Mueller, E., 2000, Mynatt, E. & Tullio, J., 2001) In the area of information visualization, there has been some interesting work in improving the interfaces of electronic calendars through fisheye views and animated zooming, for example the Perspective Wall (Robertson et al. 1993) or Datelens (Bederson et al., 2003). However, none of this previous work has addressed the unique needs of home use and in particular distributed families.

Shared information between homes and families

The HomeNet study at Carnegie Mellon (Kraut et al. 2002) indicates that computers and the Internet can contribute to coordination problems by isolating people from family and friends and increasing their daily stress levels. However, the study also suggests that when used for communication, computers and the Internet can play a positive role in keeping people connected – email, instant messaging, and family web sites are just a few of the ways the Internet helps keep people in touch. Thus, the jury is still out among many families about the value of computer technology in their daily lives. A huge diversity of ages, abilities, interests, motivations, and technologies must be accommodated. People are much more concerned about the aesthetics of technology artifacts in their home than at work (Westerlund and Lindkvist 2002) and their values may influence their use of technology (Voida and Mynatt, 2002). Finally, the line between home and work, and thus the technology needed to support both, is becoming ever more blurred, with dual income families and telecommuting now commonplace. Previous research with families revealed the importance of respecting privacy, not creating new obligations, and offering multiple modes of communication (Hindus et al. 2001). Checking on elderly relatives has been addressed with technologies such as the digital family portrait (Mynatt et al. 2001) that provides ambient information abstracted from sensor data collected in the home of the elderly parents. Others have looked at using distorted sound from the remote home to monitor activity (Marmasse and Schmandt, 2003).

Digital paper and pen

A number of researchers have recognized the benefits of digital paper, and rather than looking for ways to replace paper in the workplace or at home, they have instead explored ways to enhance it so that users can continue to rely on it. Mackay et al. (1999) summed up the reasons nicely, noting that physically, paper is lightweight, flexible, adaptable, and disposable. People can continually invent new uses for it on the fly, and manipulating and writing on paper can help aid memory. Socially, sharing it can provide peripheral awareness of other people's activities. This is especially relevant in shared calendaring, where the placement of a Post-It note or the recognition of someone else's handwriting can convey important meaning. Researchers have tried a number of techniques for augmenting paper to imbue it with some of the benefits of computerized information, such as storage, recall, editing, and linking to related media. Some solutions involved using video cameras to read information from and project information onto paper using optical character recognition (Johnson et al, 1993; Wellner, 1993). Other applications were enhanced with the use of barcodes to identify specific pieces of paper (Ishii and Ulmer, 1997; Lange et al., 1998; Nelson et al., 1999) or a similar marking called a DataGlyph invented at Xerox PARC using cameras or scanners (Grasso et al. 2000; Heiner et al. 1999; Johnson et al, 1993; Moran et al., 1999).

Recently, computer vision techniques have advanced enough to allow researchers to identify even individual Post-It notes without any special markings (Klemmer, 2001). The advent of small, inexpensive radio frequency ID (RFID) tags has lead other researchers to explore embedding them in books, documents, and business cards (Back et al. 2001; Want etal. 1999]. Others have used special graphics tablets overlaid with paper to record both real and digital ink (McGee et al. 2002; Stifelman, 1996; Seiko SmartPad). Despite the ability of these technologies to enhance paper with useful features, many require expensive and/or awkward to use tools such as high resolution video cameras or special scanners or tablets. The switching cost to invest in and adapt normal modes of operation in order to use them is high.

Most recently, researchers have succeeded in embedding tiny cameras in pens to record handwritten text [Dymetman and Copperman, 1998; Nabeshima, et al. 1995; Anoto technology; Seiko InkLink), scan typed text (Arai et al. 1997, C-Pen), or react to invisible ink embedded in the page (Paper++). These technologies show more promise for deployment in the home – they do not require investment in large or complicated equipment or reconfiguring of the home environment to accommodate them. Among the most promising technologies supporting the recognition of handwritten text is a pen and paper system created by Anoto (www.anoto.com) and sold by LogiTech (www.logitech.com). Anoto's technology works by printing a tiny pattern of uniquely spaced dots on any regular paper. A camera in the pen records the coordinates of the pen tip on any such page and sends them (e.g. via Bluetooth or USB) to a computer, PDA, or cell phone to reconstruct the handwriting. The advantage of the Anoto system compared to competitors (e.g. Seiko's InkLink) is that it really does only involve pen and paper. The pen is special, but any paper will work once it has the pattern printed on it, either by one of Anoto's many commercial paper company partners (e.g. 3M), or by developers.

Some paper calendar companies have already agreed to produce their products on Anoto-patterned paper (e.g. Mead At-A-Glance and Franklin Covey). Anoto has already built software to allow appointments created in these paper calendars to be routed directly to either Microsoft Outlook or Lotus Notes calendars. A software development kit allows developers to provide access to other programs. For users who currently have to manually synchronize either their own or others' paper and electronic calendars, this automatic linking could provide huge time savings, as well as avoid the all too common forgotten or improperly copied appointment.

However, the current support for calendaring with Anoto assumes and requires the same workplace interface imposed by the computer-based calendars they synchronize with. In the paper appointment book we received with the Anoto demo kit, users must not just simply write their appointment at the desired time, but draw a line next to it indicating the duration. There is no way to integrate input from less time-specific weekly or monthly calendars, or even less uncertain data from Post-It notes that you might want to affiliate with a specific day or week or just use as a reminder or fun note. Anoto has built support for digital Post-Its, but they are not integrated with calendaring. Worse, in Microsoft Outlook, there is no support for handwritten input, so the appointment shows up in typewritten text as "Pen Appointment" and users must open the appointment to actually view the handwritten information. Supporting the most common computer based calendaring programs is clearly necessary to integrate paper and electronic calendars, but this sort of hacking to display the output is limiting and awkward.

5 SHARED CALENDAR PROTOTYPE

Some recent research projects that address family awareness have done so with surveillance systems where the older adults are monitored by their children (Mynatt et al. 2001; Marmasse and Schmandt, 2003). This may be appropriate in some situations but we believe that more benefits could be gleaned from a symmetrical open exchange of information. Sharing of calendar information could provide a useful window into the day to day activities of remote family members. Grown children could see if their parents' activity level is normal or not (e.g. one Grandpa is mowing the lawn and going to the movies with Bob as usual, while the other has not seen anyone for a while and does not have any if his usual doctor's appointment scheduled). On the other hand, Grandma could see that her granddaughter is taking flute lessons again every Tuesday and that the next concert will be on October 15th. For those reasons and after collecting positive feedback from the family about this design principle we decided to provide entirely symmetric access to the calendars.

A common hurdle for the use of technology in extended families is the resistance many older users have to use computers as well as pointing devices. Off-the-shelf calendar software is available but designed mostly for business users and overwhelming for older adults who are very hesitant about using computers at all. Pointing devices such as the mouse can be difficult to master and intimidating. Even the pen and tablet we used for the MessageProbe were found clumsy to use and discouraged use. Our approach to address this problem was to: 1) provide alternative modes of data entry and 2) layer the calendar graphical user interface to provide a simple interface as well as more advanced ones, with a mechanism for the families to specify – or request to us - what interface they would use. To allow the grandparents to enter data in the simplest way possible we investigated the use of a digital pen and digital paper.

Other researchers have recognized the important affordances of paper in many domains and sought to augment it with electronic information using cameras, tags, and special tablets (Johnson, et al. 1993; Wellner, 1993; Stifelman, 1996; Mackay and Fayard, 1999; Klemmer et al. 2001; Guimbretiere, 2003). We see digital paper as a Trojan horse to introduce the grandparents to the shared calendars – and maybe computers in general – but our hypothesis and goal is that some users will gently make the switch to the keyboard based interfaces that will give them access to more features, while others will prefer the simpler interface which limit the number of features.

Description of the interface

The basic principle of the shared family calendar interface that we built is to tile multiple calendars next to each other and synchronize their navigation (Fig. 9). A click on a day enlarges the day on all calendars and makes it more readable (Fig 10). Everyone can see all the calendars on their computer screen, but each household has the ability to hide the calendars they do not want to see to make more room for the others. For example, grandparents will most likely choose to see their own calendar and the one(s) of their children, but not the calendar of the other grandparents (Fig. 11). In the simple mode of the interface, only a week view is available and all calendars are coordinated and can be navigated at once with the mouse and the keyboard. The next and previous arrow keys select and enlarge the next or previous day, the up or down arrows switch to the previous or next week, and the escape keys un-enlarge the currently selected day to make all days of similar size. Users can also select the size of the characters. Bigger characters are more readable, but may lead to multi line labels and some of the text of events to disappear until the day is selected and enlarged. At the top left of the screen a home icon allows users to return to the current week with the current day highlighted. The interface was built by extending DateLens (Bederson et al., in press) and takes advantage of its animated transitions.

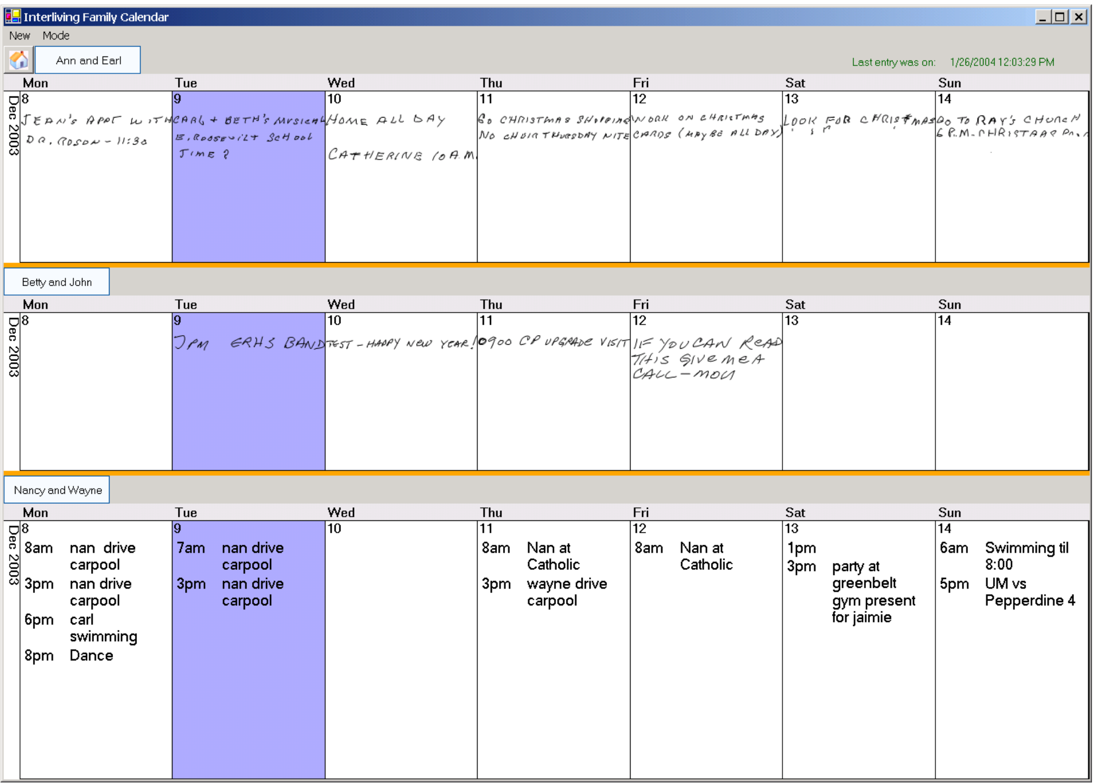


Fig 9: The basic interface shows a week view of the 3 calendars side by side. The information on the top two calendars was handwritten by the grandparents. The information in the lower calendar was entered with Microsoft Outlook by the junior family.

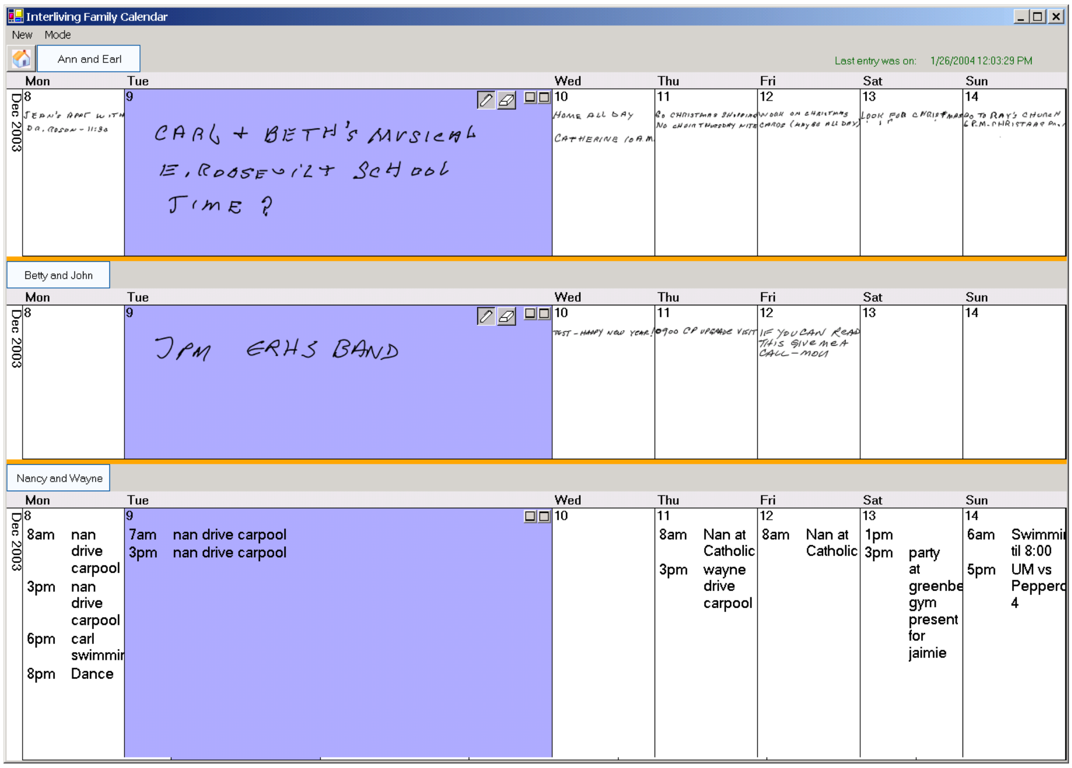
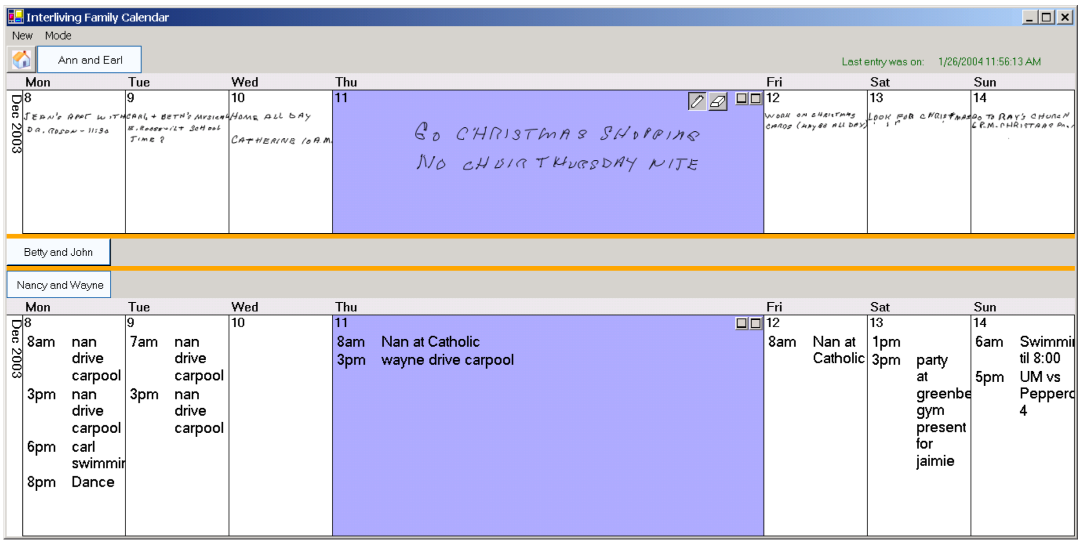


Fig 10: Clicking on a day enlarge the day to improve readability.



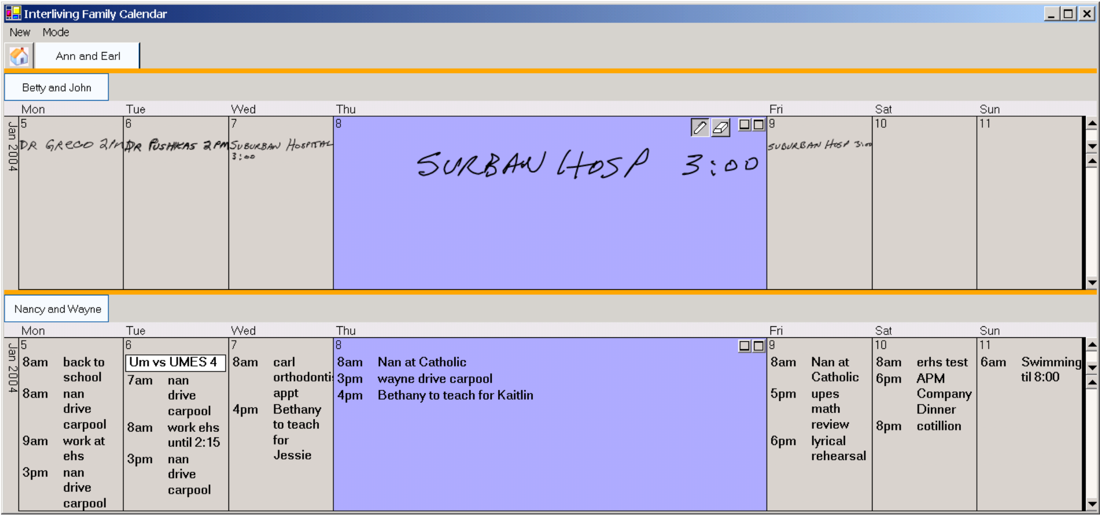


Fig. 11 a and b: The grand parents chose to see only their calendar and the one of their children.

The methods of data entry can vary. The simplest method which was used for the grandparents is to write on calendar printed on digital paper using a digital pen (Fig. 12). When the pen is placed in its cradle the information is transferred to the computer and appears on the corresponding day.

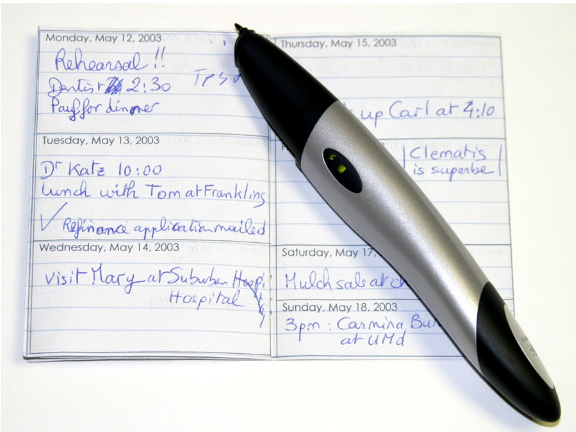


Fig 12: The grandparents write on their small pocket calendar printed on digital paper (left) and replace the pen on the cradle to transfer the information to the computer (right).

Advanced users (for example the junior family) can use Microsoft Outlook to enter all the calendar information. That allows them to specify the start and end time of an event, edit their descriptions, or delete or move events. They can set reminders, enter repetitive events all at once and specify their periodicity, make events private, and enter as many events as needed for any particular day. The interface for those numerous functions seems fairly simple for users with computer experience but is overwhelming for users with limited computer knowledge. It requires users to memorize long series of actions for navigating menus, typing, setting widgets and dragging icons or scrollbars, which are very difficult for novice older adult users.

The data entered with the digital paper calendar appears exactly as it appears on paper, rescaled as needed to fit the screen space. The data entered with Outlook appears as text that can be laid out to fit the screen space.

Implementation

The calendar was implemented as a special version of Datelens (Bederson et al. 2003) (Fig. 13). It uses a layered architecture that automates Microsoft Outlook in the background, while providing a custom view to the families. This approach enables us to create our own visualizations tailored for novice users by using any desirable features already built into Outlook, while filtering out the more complicated features. In particular it allows us to use a standard Microsoft Exchange server running at the University of Maryland to coordinate and synchronize all the calendars in the distributed households. A single Exchange server mail account was created for the family, and three calendar folders were created for that user (a standard capability of Outlook). The calendar information for each household is stored in a different calendar folder, and the three calendars are synchronized periodically on the network.

Our shared calendar interface software reads the three Outlook calendars and presents the information on a single screen. The paper and pen data input interface uses Logitech digital pens with Anoto technology. We printed the calendar ourselves on commercially available pads of digital paper with Anoto patterns. This allowed us to create calendars of the size and layout we wanted to fit the needs of our families. When users write on the calendar and replace the pen on the cradle, the Anoto software generates an XML document to describe the strokes on the paper. All the ink written on a given page of Anoto paper is saved in a single XML file. For our software to know which portion of the XML file corresponds to each day of the calendar, we print the calendar double-sided on consecutive pages and pass the Anoto page number of the 1st day as an attribute to our calendar software. We parse that XML document and using the Tablet PC Software Development Kit, we convert it to a set of ink objects (one per day of the calendar, i.e. per rectangular portion of a page) that are saved as individual attachments to appointments in the Microsoft Outlook. Our shared family calendar software renders all the ink objects in the calendar displays. It also listens for updates in the Outlook calendar folders which occur either when local users enter new information, or remote users have entered new data and Outlook has synchronized the three calendars.

We chose not to use optical character recognition to convert the handwritten information because it would force the families to write more deliberately, and we want to preserve the benefit of unconstrained handwriting. Because of the choice of using a small pocket paper calendar, there was no room for laying out the hours of the day as found on day-by-day calendars or large weekly calendars. Users of the paper calendars can choose to write a begin time for an event, or not.

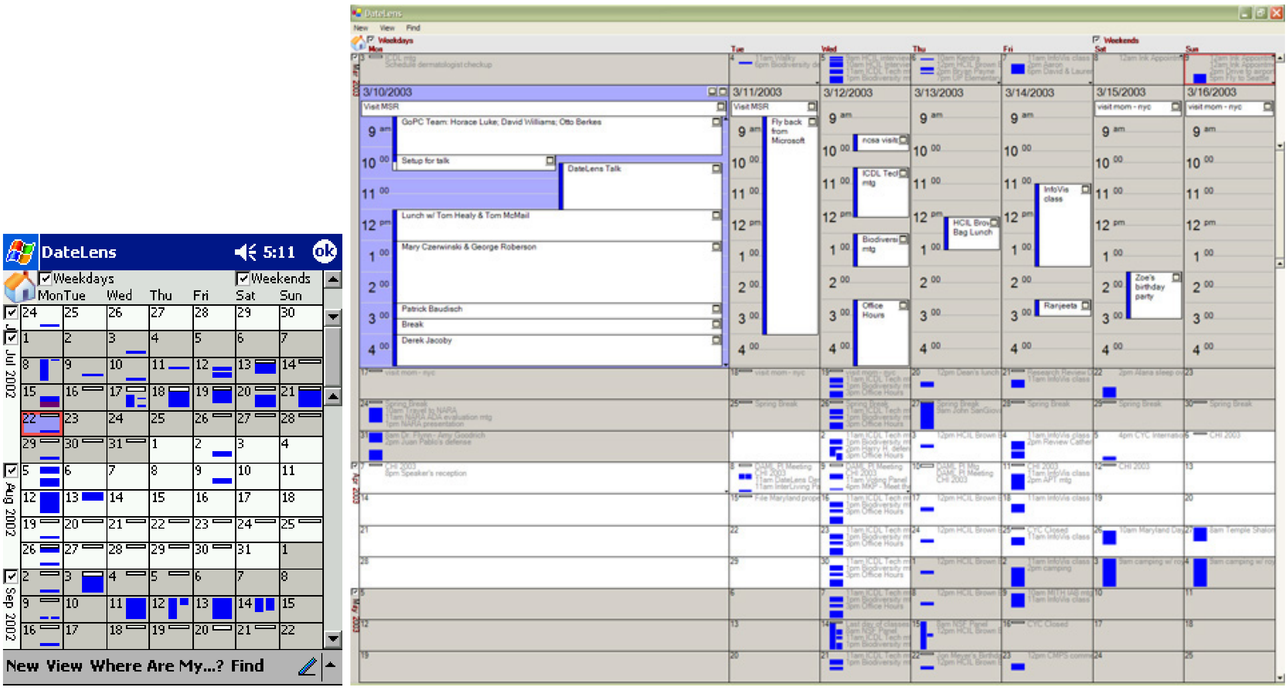


Fig. 13: DateLens was designed for small mobile devices (left) but can also be used as the desktop application. It uses fisheye views, multiple views and visual data summaries to assist users navigate the calendar.

We hypothesized that advanced users – i.e. the junior family adults – might also want to use the full DateLens interface to have access to scrollable monthly and yearly views, or search and filter on the three calendars, or decouple the calendars to view and compare different weeks in different calendars, at the price of increased complexity. Therefore, options were added to allow users to access such functionality within the shared calendar interface if they chose to. In this more advanced mode the three calendars are decoupled, allowing the individual scrolling of calendars. Moving a sliders' range thumbs also allows users to change the number of weeks seen in each calendar, from one to 3 or 4 for a monthly view. Windows are resizable and individual home icons allow users to return to home for each individual calendar. Users can also enter events using the keyboard and mouse using menus and a form fill-in similar to Outlook's new event interface.

FIELD STUDY OF THE SHARED CALENDARS

Deployment in the families - Dealing with scheduling delays and technical difficulties

The prototype was installed in the three households and is still in use. Deployment was significantly more difficult than we anticipated, particularly in dealing with aspects relating to networking. There were general networking problems which were compounded by the requirements of our University network as described later. The deployment in the families started in early September but we were able to collect usage data only at the end of October. This surprising delay was due to a combination of scheduling problems and technical difficulties.

Even though our own schedule was fairly flexible and the families live close to campus, scheduling visits for interviews or to install software or debug problems sometimes took weeks to schedule. The junior family is very busy even during evenings and weekends, and special events such as holidays or trips constrained our visits as well. For the grandparents there was either no problem setting appointments for the next day or we had to wait several weeks. Travel, moving, illness or illness of close friends sometimes created unexpected long delays. It is unrealistic to believe that older adults are always available and ready to deal with the complexity of interviews, computer installation, training and operation.

Despite the fact that we use fairly standard technology, we had many technical problems, most of them unrelated to the software we had written ourselves. One important constraint was that we had to use the computers of the families (as opposed to new hardware that could be set up in the lab), and therefore we needed to minimize disruptions to their current setup. Grandparents were happy to have us come and upgrade their new computer with more memory or new software, but changes were not acceptable to the junior family, which relies so much on the computer that they dread the idea of having us modify anything in their computer. Of course we had to make some changes but this created a great deal of anxiety for the family, and for us as we feared erasing precious calendar information while we were setting up the synchronization with the network server or upgrading to a newer version of Office to allow such synchronization. We also struggled with using different versions of Windows and Office. The three computers had three different configurations. The options and setting we had to set for Outlook were accessed through different menu hierarchies and often used different names. When something went wrong debugging could not always be done immediately. We consistently underestimated the amount of time require to install software and even updates.

We often had to schedule additional visits to finish installing or setting up software, which could again delay installation for a week or so. The final details were difficult to arrange as we could not be in all three houses and in the lab at once to correct problems. One example of this problem occurred after we installed the junior family version, and proceeded to install the software on one of the grandparent computers. The installation went well, ink could be written on the paper calendar, the Outlook synchronization seemed to work properly, and we could see the junior family calendar from the grandparents' house. We left and started celebrating but the next day we had a report of ink calendar events being duplicated at random in the calendar and of duplicated events appearing in the junior calendar exactly one day off. After some extreme puzzlement and a few days of investigation it turned out that the grandparent's computer had a different daylight saving option which had no effect locally but affected synchronization. The anxiety ran high as we had to clear the junior calendar by hand of all the duplicate events and clean and reset the paper calendar XML files in all three households. Fortunately no permanent damage was done and after about two months of setup time we were ready to really start the field study.

Even today some problems remain: Appropriate University security policies require a Virtual Private Network (VPN) to be setup before connecting to the Microsoft Exchange server. But our families have been experiencing consistent problems with keeping that connection alive. We tried to train the families to recognize that the VPN was down and to restart it, but this was not effective. Finally, we created a small program to monitor the status of the VPN and restart it automatically. Bugs within Outlook have also created minor problems that still remain. For example, events sometimes get duplicated when the calendar information is accessed by an outside program (it appears as if the event had been modified and the two variants are kept, see Fig. 10 for examples of duplicated events).

Overall results

After two months of use, the main finding of the field test is that grandparents have strongly indicated an appreciation of being able to see the schedule of their children and grandchildren. Both sets of grandparents report checking the calendar at least once a day. They have entered data on the paper calendar on a semi-regular basis, when the connection and software have been functional. They regularly apologized to us for not having that many things to include in the calendar. The junior family on the other hand has been so plagued with technical problems that they have not used the shared calendar very often. They did continue to use Outlook regularly as before, and the mere synchronization of the calendars allows their parents to review up-to-date calendar information. The junior family repeatedly indicated that their limited use was due to the technical challenges and not lack of interest. Because the junior family is currently checking the grandparent's calendar very seldomly, the grandparent's motivation to enter information in their calendar is limited. The maternal grandparents never had any difficulty using the pen or the calendar, but clearly indicated that they were not motivated to enter data if their daughter was not going to look at it. In two cases he even entered illogical entries in his calendar to see if that would be noticed by the others. Despite limited use, both sets of grandparents spontaneously requested new paper calendars when the first one expired, without us asking them if they were interested in continuing this experiment.

The pen and paper calendar was easy to explain and quickly learned. "How much simpler could it be?" said one of the grandfathers. The only problem encountered with the pen was that it had to be returned to the cradle the proper way and not upside down. There was a problem on the first day but never again after that. The pen never ran out of batteries, mostly because it was usually kept in its cradle. It was found unnecessary to carry it around since the data was not transferred until the pen was returned.

Training was always an important part of the visits to the paternal grandparents. During the initial visits we were struck by the strong interest of the grandparents in seeing the schedules of their children. While we were presenting information about how to use the interface, they were barely paying attention to us and our explanations but instead carefully studying the calendar and discussing together some of the implications of what they had found (e.g. "We should move the birthday dinner earlier because there is a music lesson later that day"). This interest was made clear at every visit when we had to restart the computer or software because something had been disconnected. We also spend a fair amount of our time discussing how to use Microsoft Word and how to turn off features such as the automatic spell checker, or how to eliminate the annoying popup ads that appear when browsing the internet.

After a month and a half of use, the paternal grandmother requested the ability to enter appointments directly into the calendar by typing. She explained that while the pen-based interface was simple, she felt that her handwriting didn't look nice enough on the screen. She used to type on a typewriter so typing was not a problem and she wanted her text to look as nice as the text entered by her children (Fig. 14). We switched her software to be in the "intermediate" mode that allowed her to enter appointments directly. The interface proposed is similar to Outlook, but simpler (Fig 15). Nevertheless it is still difficult for her to enter events with the keyboard and we worked together with her to prepare a set of written directions to help her remember what to do. This feature has not been used much and we suspect that it is too complex to be used in its current form. This request indicates that digital paper may be a powerful tool to introduce older adults to computers, but that once they feel more comfortable, they may be ready to switch to more conventional modes of interaction. While we were explaining how to enter text with the keyboard to his wife, the grandfather indicated that he still much preferred to use the paper calendar and had no intention of using the keyboard.

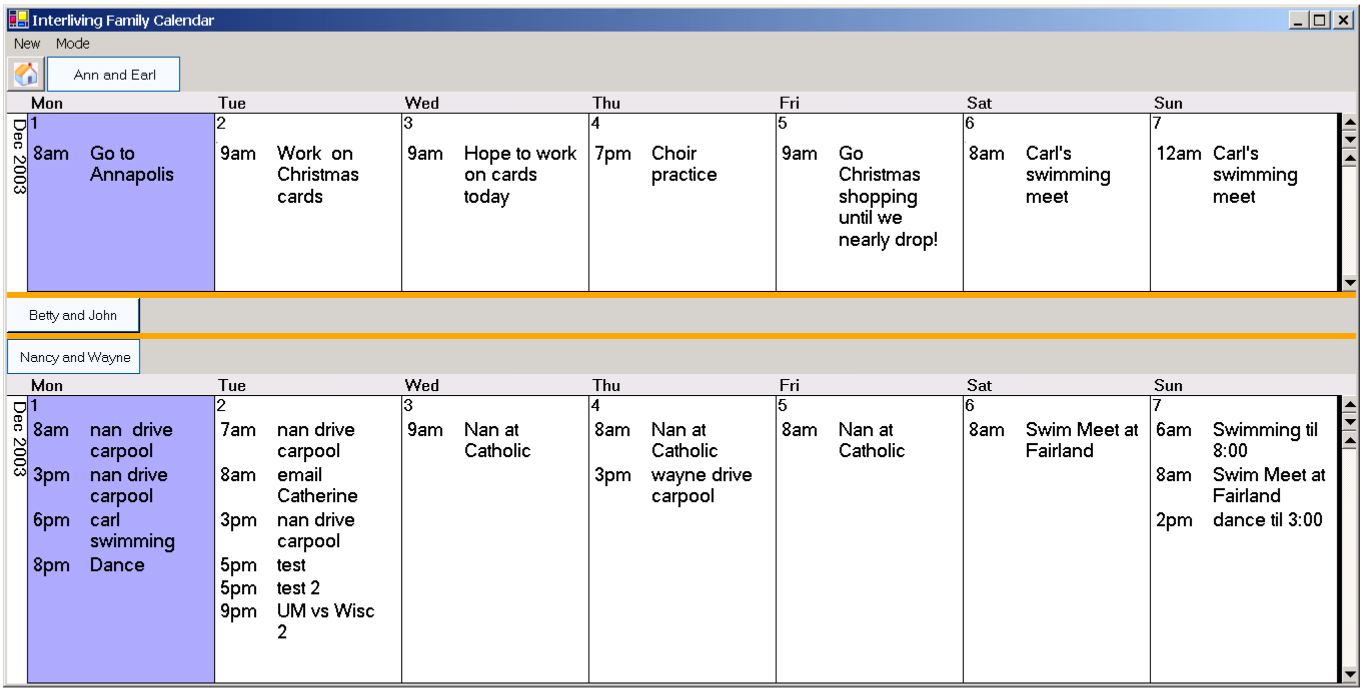


Fig. 14: One of the grandmothers found typed text nicer looking that the handwriting. Other grandparents preferred the simplicity of the paper calendar.

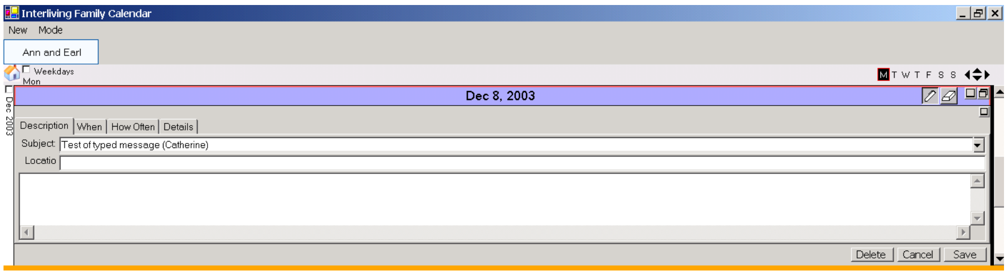


Fig. 15: To type the event description users need to use a more advanced version, which has a NEW button to create new events. Editing and deleting events can also become more challenging.

Incremental changes made to the interface

Through the course of our experiment, we have gone through several iterations of the software. The changes have been driven by comments from the families using the application.

The initial improvements were made to improve the readability of the text and ink. The grandparents said that they could not easily read the text of the events, and complained that the text was often clipped while there was plenty of space to display it (Fig 16). The day names (Monday, Tuesday etc.) were also hard to read. We added an option for setting the font size of the text, and displayed the event as a simple list instead of trying to place the event at a fixed position corresponding to the time of the event. This also reduced the need for scrolling when events occurred early or late (in fact it eliminated it entirely during the testing).

To increase the readability of the ink we first tried to set a limit to the rescaling of the ink, which lead to clipping of some of the data. This was found misleading as some information was simply never noticed, and it was decided that it was better to be able to see the whole content than to clip it, even if this meant that the ink would appear smaller on the display. On the other hand, it was found acceptable to pan the ink on the available display space to see it better. For example, if all the text for a day was handwritten at the bottom right of a rectangle on paper, it would still appear zoomed in as much as possible to fit the area of the display corresponding to that day, making it more readable.

As we tested the usability of the interface, we also removed more DateLens features that were not needed for the family calendar. For example, the Weekend and Weekdays buttons were removed (all days were found equally important), the scroll bars were removed (the weekly calendar was found sufficient and the arrow keys fine to navigate), and the calendars were labeled with users names instead of generic labels such as “Calendar 2”.

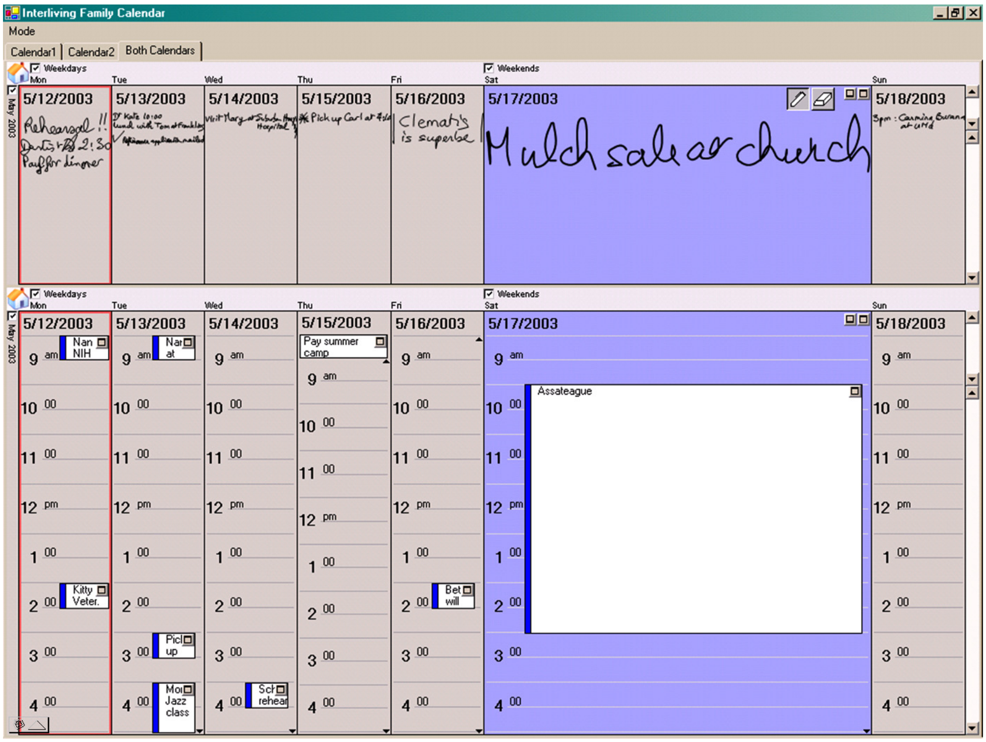


Fig. 16: An early version of the interface with unnecessary controls, event descriptions displayed in too small a font and often clipped.

A concern for the junior family was the issue of privacy. Even though this would rarely be necessary it was deemed important to provide a mechanism to “hide” certain events when needed. This could easily be addressed by the privacy feature of Outlook. When necessary, events can be made private when entering them using Outlook, and the shared family calendar simply ignores them. This has only been used for one event during our field study. Grandparents could make appointments private by simply writing with an ordinary pen instead of the digital pen (this has not been used during the test).

CONCLUSIONS

Our interviews demonstrated that even closely knit families that stay in touch through regular visits and phone conversations still have difficulties remembering the dates of each others’ activities. Our investigation suggests that users who maintain home calendars will glean valuable information from peeking at each other’s calendar, and that the heightened sense of awareness of current and planned activities might actually increase the amount of communication (“So, what did the doctor tell you?” or

"When you go on that overnight business next week, check the Van Gogh exhibit"), and potentially facilitate coordination. We observed a clear increased awareness of the junior family's activities by the grandparents. Technical problems and the overwhelmingly busy lives of the junior family limited their use of the shared calendar but their impressions were positive. We observed that different family members used the calendar in different ways. For example, one grandfather diligently recorded many events, while one grandmother never really touched the computer but regularly went to simply look at the screen. We also confirmed that the digital pen and paper was an effective way to create easy-to-learn, non-threatening technology for older adults. All three household chose to continue the testing for a few more months. We hope that as use increases, the families will also start using the shared calendar to plan tasks that require coordinating the schedules of multiple people.

ACKNOWLEDGMENTS

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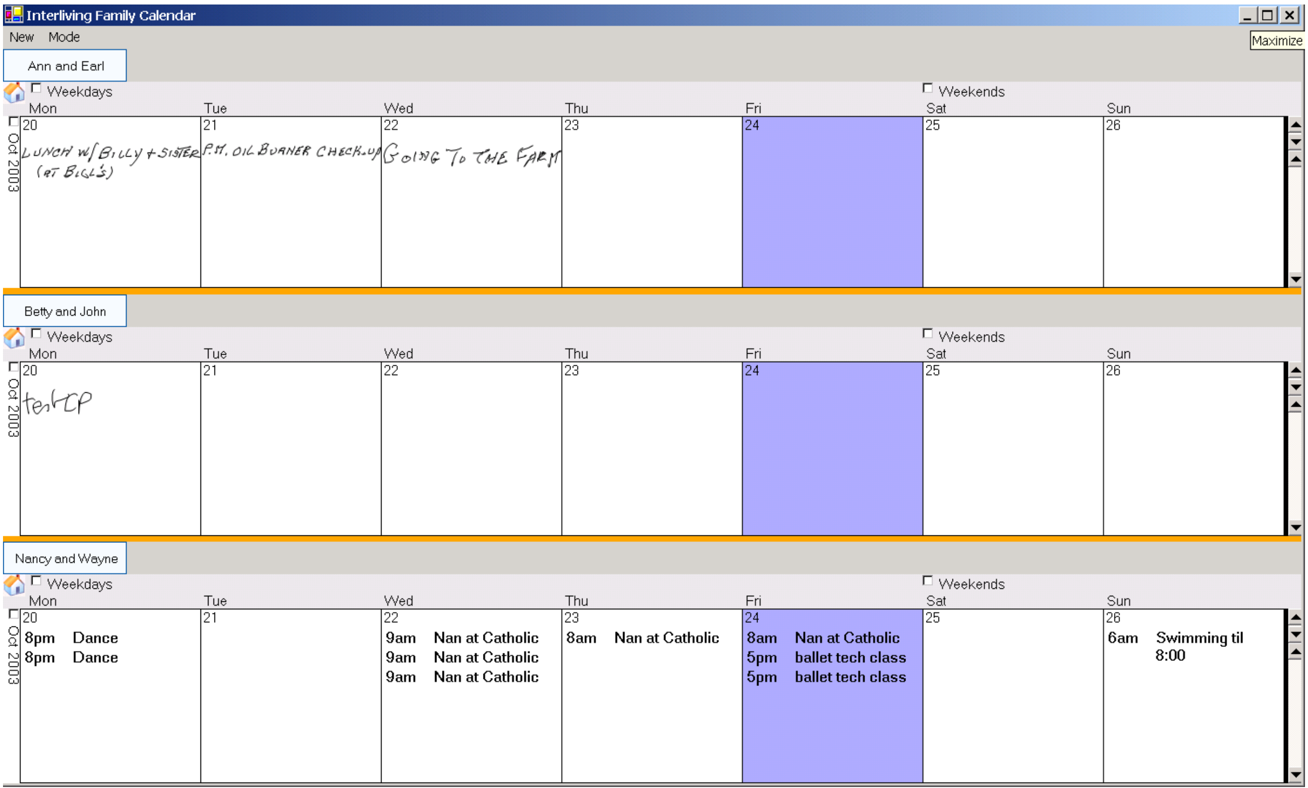
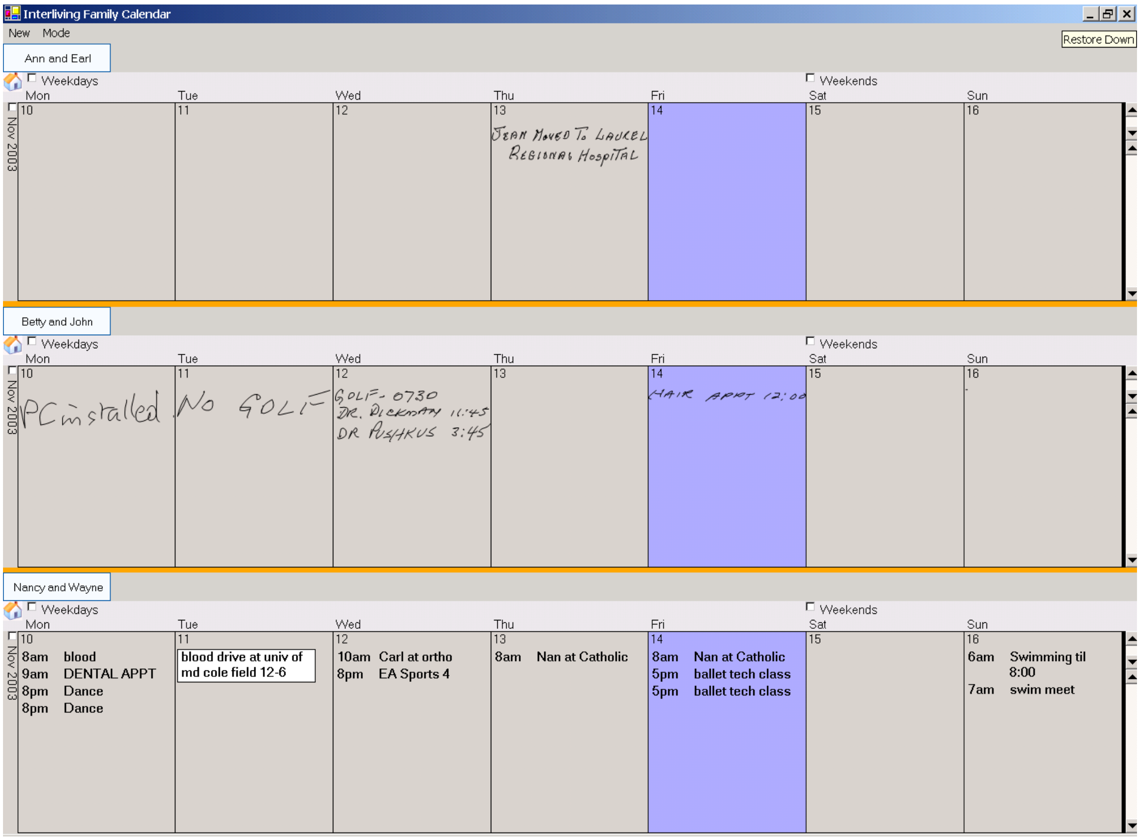
Appendix A: Additional screen prints at different stages of the field test.

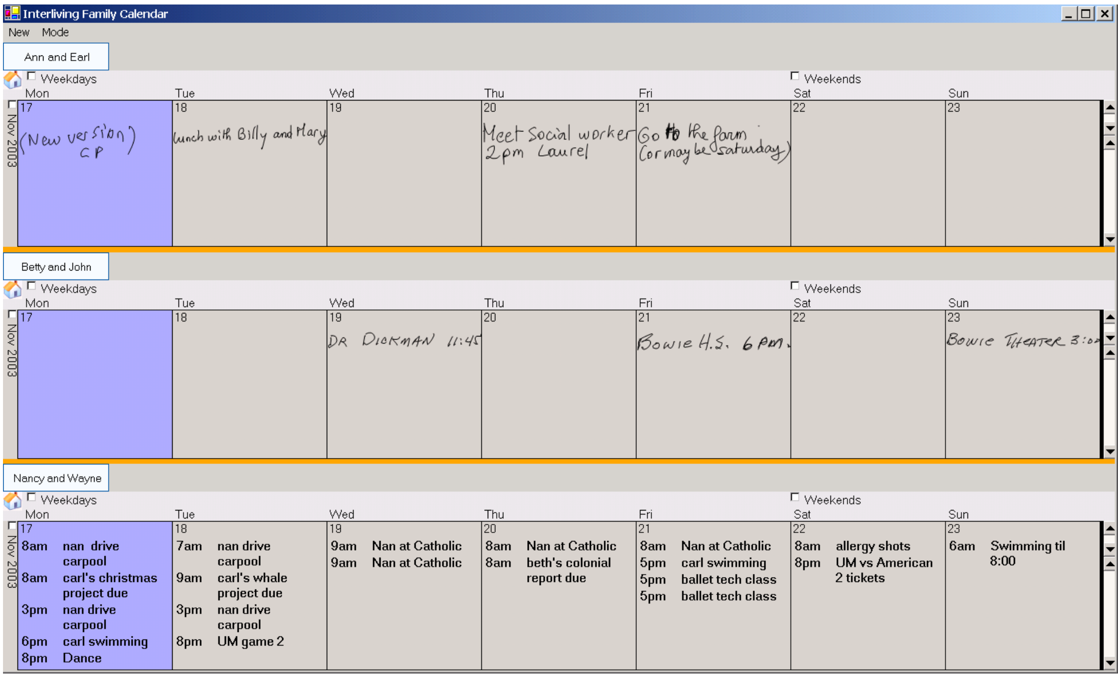


The 1st week of the study, running only in two households. Some events became duplicated later on.

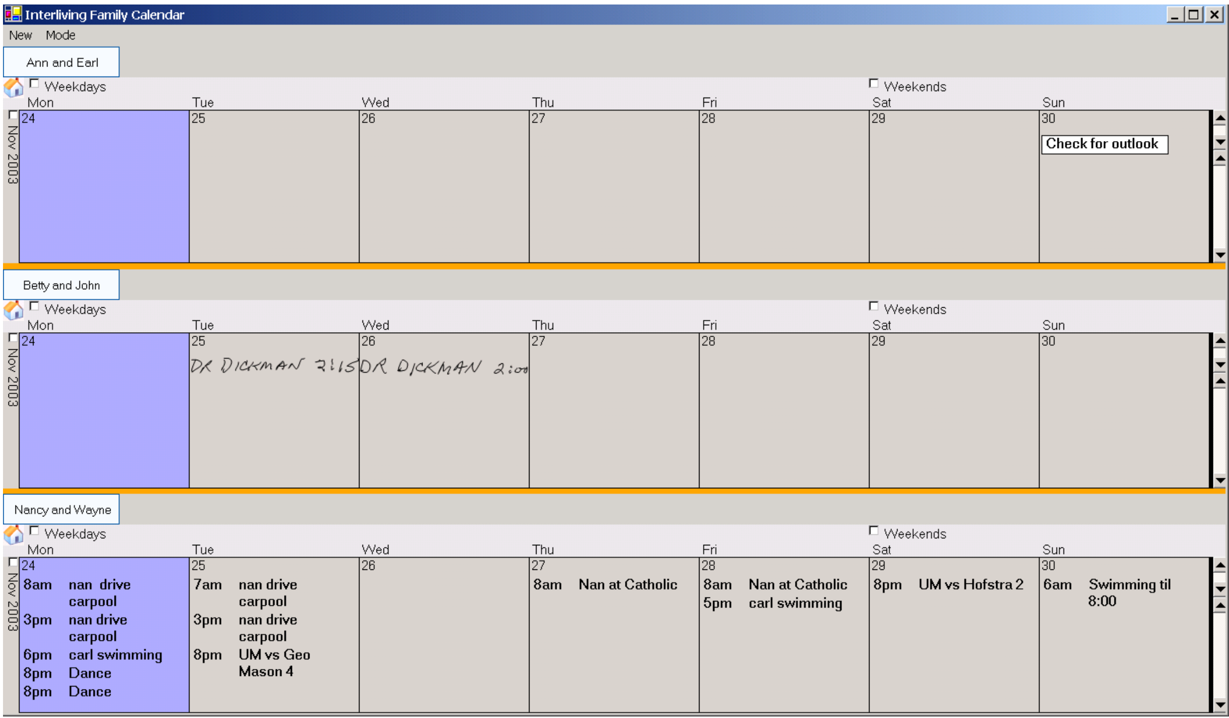


Third week. The third household joins in.

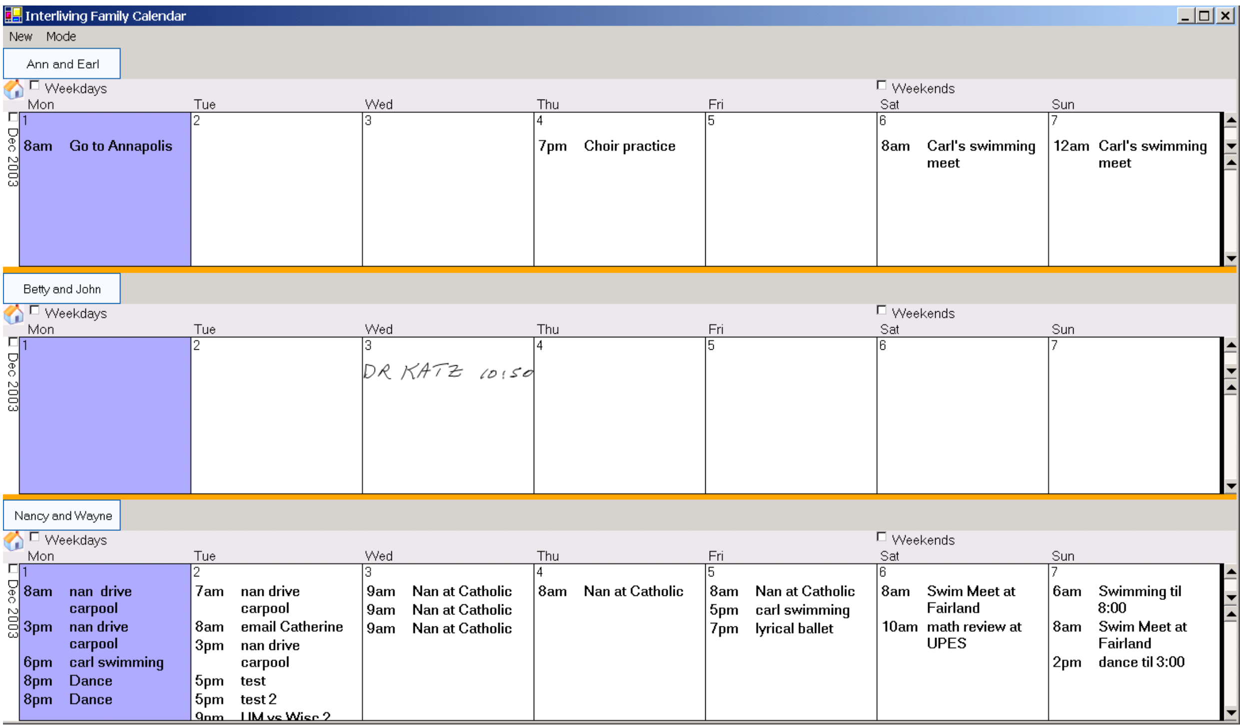
A close friend is ill and the paternal grandparents become mostly unavailable.

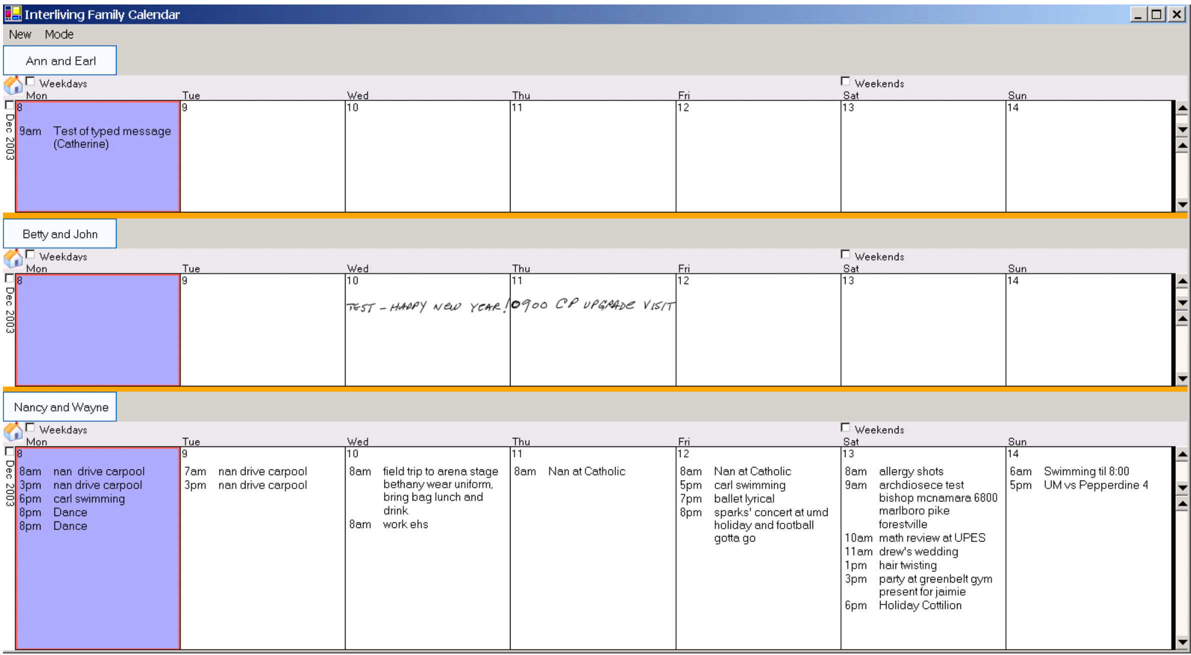


Fourth week

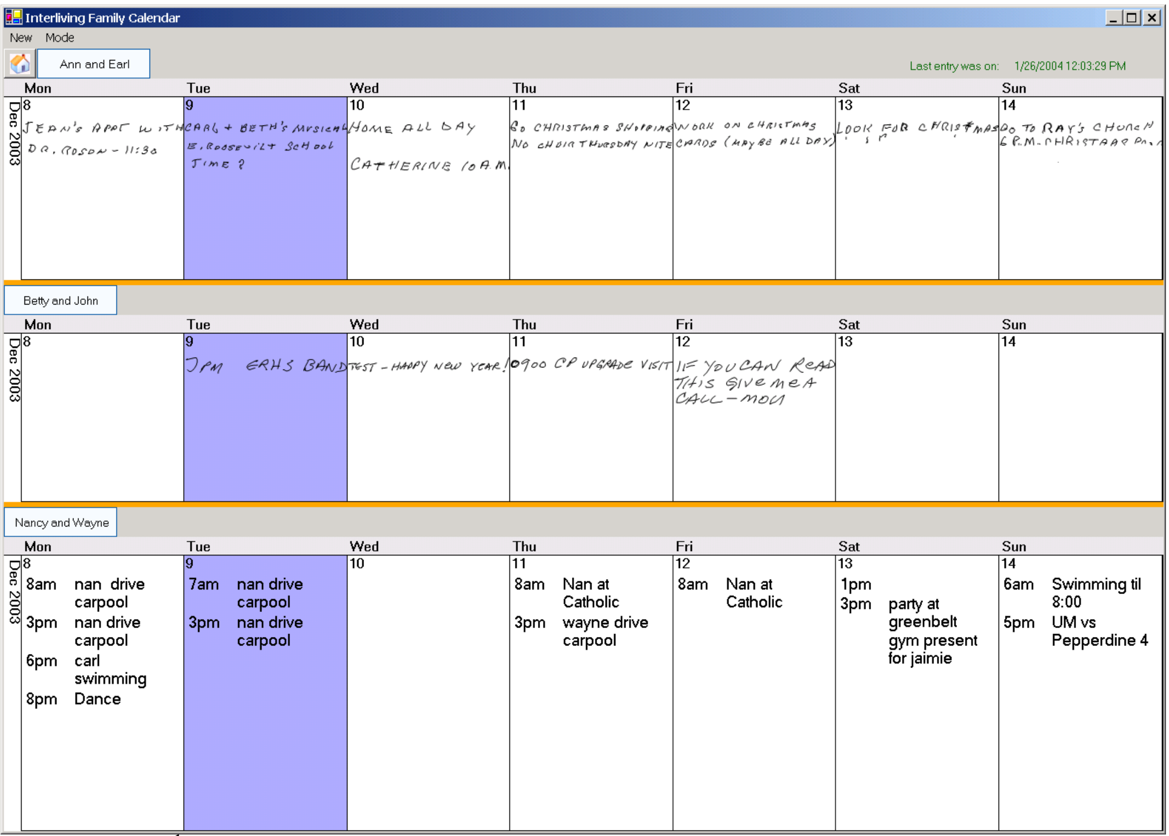


Start of Fifth week





Start of 6th week (see next Figure for later view of that week)



Same week 6th, more handwriting but some of the junior family events have been removed. This is the final week included in the paper calendars. Grandparents requested new calendars.

3. Results and follow-up possibilities

3. Results and follow-up possibilities

Here we present results from the interLiving project and point at follow-up possibilities, of which some, especially the FamilyNet, are so promising that we apply for continued funding nationally and from the EU.

3.1 Results and shortcomings

The InterLiving process has successfully:

- increased our understanding of multi-household family communication, via a longitudinal study of six families, and of co-adaptation of technology by users. This has involved long-term cooperative design with 50 European family members, aged between 1 and 76, ensuring that the resulting technology is both interesting and desirable to users.
- generated novel design methods (specifically, Technology Probes and the Interactive Thread as design methods), which have been published and actively shared with other Disappearing Computer projects.
- developed and tested innovative distributed communication artefacts using shared surfaces (including three technology probes: VideoProbe, MessageProbe, StoryTable and four prototypes: MirrorSpace (proximity-based shared video), FamilyCalendar (paper interface to an on-line calendar), Backdoor (shared informal message board) and InkPad (shared disappearing ink); and
- identified the foundation for a new form of communication appliance (a secure, limited network and archive for families), which we expect to form the basis for a new research project.

The project has been less successful in the ambitions to:

- install these technologies in homes so the families can live with them over weeks and months. The main obstacle has been unstable services and connections from network providers, still a quite shaky business. In spite of that some technologies have been used by some families, each family has used at least one, resulting in identification both of new functionalities (which have been fed into later artifacts) and new uses of the technology. With better reliability from network providers we would have been able to make much more such experiences, though.

The innovations in context, process and technology result from our multi-disciplinary approach and have served both to define new research problems and to solve them.

The design methods described above have already begun to be adopted by other researchers (IBM Research, University of Toronto) and have been actively sought by industry (Philips, VTT, Nokia) to help them define requirements for technologies for the home. Our longitudinal studies of families provide unique insights into family communication and our published results will add to the relevant research literature. The specific prototypes described above have been or will be published in research articles, the software for some is currently available via the web under a free software licence, and the MirrorSpace has been exhibited in several prestigious exhibitions in France and is been exhibited at the Pompidou Centre in Paris in November-December 2003 an will be shown at the Art Grandeur Nature exhibition in Paris May- July 2004.

However, the largest potential long-term impact will derive from our strategy for developing and deploying "communication appliances". Although this will require additional research in a future project, the expected impact could be very large, enabling a whole new set of technology artefacts of a style that are currently limited to laboratory research prototypes, but should be usable by a large proportion of the general public.

We began this project with a research philosophy (multi-disciplinary, collaborative design), a perspective (families first, not technologies), and a desire to explore a new design space (technologies for distributed, multi-generational families). We have clearly met all of our original stated objectives in terms of work with families, development and sharing of innovative design methods and creation of novel communication technologies. We have also been extremely fortunate to identify a whole new research area and we are now ready for the next step, which is to clearly articulate this new type of family network and its associated applications.

The computer industry has repeatedly demonstrated its skill in developing faster, cheaper, smaller, and smarter networked devices. Yet, the most difficult challenge is often "truly understanding and satisfying user needs." Just *what* technology makes sense for ordinary people, in the course of their everyday lives? Although general purpose *information appliances* have been promised for almost 20 years, the vision remains largely unfulfilled. Despite a few notable exceptions, particularly mobile telephones and SMS messaging, many of the promised devices have failed as products (as witnessed by reports from E-Bay of increasing numbers of barely-used e-gadgets for sale) or remained in the lab.

Our own research, involving longitudinal, participatory design with families at home, shows that people want *communication appliances*, defined as simple-to-use, single-function devices that let people communicate, passively or actively 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. Communication can also occur over time, including leaving quick messages for oneself and others to preserving and sharing memories over years.

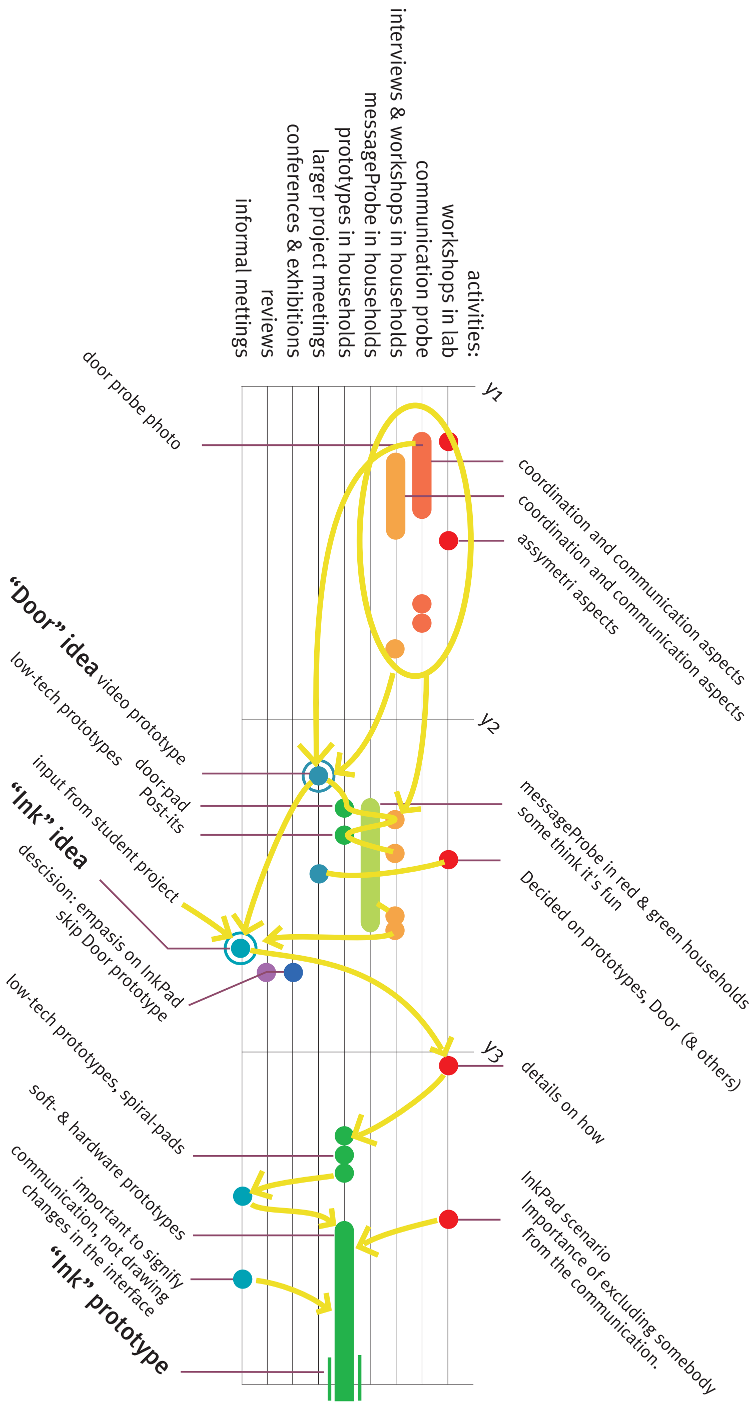
We intend to follow up this insight mainly through the FamilyNet, which we already started prototyping, and communication appliances such as MirrorSpace and InkPad over FamilyNet.

3.2 Technology development with design method influence

A very important quality of the interLiving project is the development of technical prototypes, refining the concepts, under strong influence of many design methods.

In the figure below we illustrate, as an example, how the Door probe developed conceptually to the Ink prototype, and how the design methods have influenced this evolution.

This is described futher in 2.2.2, InkPad development and use.



3.3 Follow-up: FamilyNet

We plan to develop and test a new form of communication appliance. As before, we will actively work with real users in real use settings and will collaboratively develop and test innovative working prototypes that ordinary people can weave into their everyday lives.

A key technical research focus will be to define the architecture and protocols necessary for the infrastructure for these communication appliances. Our goal is to provide an open format with a clearly specified protocol that enables a wide variety of developers, from individuals with specific needs to major corporations with large customer bases, to create communication appliances that rely upon a common foundation. Like the world-wide-web, this would be a European-led research project that has the potential to significantly improve how people interact with each other.

In an application to EU FET Open for support we specifically describe the goals as the following types of results.

Technology

1. *FamilyNet* prototype
    - Open source architecture, functional specification and software
    - Working prototype of FamilyNet (hardware & software)
    - Multi-layer user interface
      (including a tangible interface for non-technical users)
2. Three diverse *Communication Appliances*
    - Video prototypes to illustrate the design space
    - Implemented prototypes (hardware & software)
    - Tests across media and communication-style dimensions
3. Published research articles on: architecture, services, FamilyNet, Communication Appliances

Social Science

1. Design specifications for novel interfaces for communication appliances
2. Development and publication of new design methods
3. Published research articles on observations and design work with people
4. Published research articles on tests of the technology in real-world settings

Design

1. Creation of innovative communication appliances
2. Development and publication of new design methods
3. Exhibits of communication appliances in museums, exhibitions and/or conferences

In the research and development the longitudinal contacts with families and households in different generations established within interLiving is a great asset. We intend to continue working with some individuals and connections of the current families and also recruit new individuals.