Methods and Guidelines for the Design and Development of Domestic Ubiquitous Computing Applications

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ABSTRACT
In our research we investigate how applications can be conceived, designed, and implemented that fit into people's home environments. In particular we describe our method of how user centred design and participatory design can be appropriated to find users' requirements and design ideas for ubiquitous computing applications for the home. In our example we focus on information presentation and display appliances. In the process we go from individual solutions, fitting a single persona each, to more generic prototypes. Based on this we provide a set of guidelines for the design of display appliances in the home environment.

Categories and Subject Descriptors
H.5.2 [**User Interfaces**]: *Interaction styles, User-centered design, Prototyping, Theory and methods*

General Terms
Design, Human Factors.

1. INTRODUCTION
With the emergence of Ubicomp scenarios for everyday life, research has been addressing domestic environments encountering new challenges in the elicitation and specification of user requirements. Scenarios of ubiquitous computing, context awareness, and automation of appliances have been explored in living laboratories. However, the research has had so far little impact on ordinary homes, and the take-up of ubiquitous computing technologies in the home has been marginal so far.

Users' acceptance of the system, their privacy and trust concerns, together with controllability and learnability of the interface are main concerns that need to be addressed. This has suggested academic research to adopt ethnographic approaches to investigate this domain and look at its social patterns [1], [3]. Such research has its focus in understanding the users' needs but is in many cases very conservative with regard to technology. In our approach we acknowledge the importance of ethnographic research, but extend it by the in-situ introduction and discussion of new technology with people in their home environment to gather design ideas.

To explore this approach further and to evaluate our methodology we investigated the use of displays in the home as a potential application area for ubiquitous computing.

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1.1 Taxonomy of Domestic Display Artefacts
In everyday life, people use a great number and variety of display artefacts: calendars, post-its, posters and pictures. Display artefacts in home environments have many different forms, ranging from paper displays to objects that people make visible to themselves or others. In our analysis we distinguish five kinds of display artefacts:

- reminder for future actions (e.g. a post-it, a shopping list);
- reminder of past events (e.g. cards of a past concert);
- awareness media (e.g. a calendar, the transportation timetable);
- communication media (e.g. a message board, a post-it on a door);
- decorative (e.g. a poster, a sculpture, a puppet).

The use of such categorization responds to the goal of understanding why and how people tend to use some kind of displays rather then others. Understanding their choices will help to identify contexts where technology and additional information makes sense in the house.

2. RESEARCHING THE DOMESTIC
The study was carried out in a major European city. In total 14 people took part, seven women and seven men in age from 23 to 44, and we visited 6 households. The participants had diverse academic and professional backgrounds.

We adopted a multi-techniques investigation which combines the methods of contextual inquiry, cultural probes [4], technology probes [5], scenarios-based participatory design and interviews in a qualitative research approach. This combination of techniques is extended by the use of functional technology probes to engage the user with potential solutions. The goal is to identify and interpret the attitude and the emotional aspects of users' behaviours in the house, to investigate how people think about communication in the domestic environment, what motivates, drives and pleases them.

In summary the following steps are followed:

- **Step 1: Technology research**, researchers have to get an understanding of potential technologies, their advantages and limitations as well as typical application areas;
- **Step 2: Interview in the home environment,** getting explanations why people organize their environment in the way

they do it; describing the environment systematically with respect to the technologies investigated;

- **Step 3: Cultural probes**, investigating how people deal with certain objects, spaces, places, in their environment. The focus is on artefacts that relate to the technologies that are investigated;
- **Step 4: Technology probes**, inspiring discussion by presenting functional prototypes in the situation of the users home;
- **Step 5: Educate the user on technologies**, give the user a quick and easy to understand overview of potential technologies that are available. This needs to be in the language of the user and should also communicate pros and cons, as well as trade-offs of certain technologies;
- **Step 6: Participatory design session**, sketch a design for a specific persona, focusing on an appliance the users would like to have for their environment;
- **Step 7: Creating prototypes from person inspired designs,** identifying generic technology artefacts or platforms for the home, based on the specific user driven sketches from step 6.

In the following we discuss step 4 and step 5 in more detail as they introduce novel issues in the design process.

2.1 Technology Probes and User Education

Technology probes were used in order to stimulate people's creativity and inspire ideas for new technology in the domestic environment, similar to [5]. In comparison our probes were deliberately less finalized in terms of casing and hardware design as they were meant to show the possible functionalities. This choice was motivated by the intention to avoid people's concentration on the look of the probe, but rather to stimulate their imagination in terms of scenarios of use of such technology. Presenting unfinished but working prototypes we felt that users had no hesitation when suggesting radical new form factors, usage scenarios, and applications. This is in line with findings for prototyping in graphical user interfaces [2].

We realized that it can be very hard for people, especially when they do not have a technical background, to engage with abstract descriptions of technologies. The reactions without probes that we got can be grouped in two main categories:

- **"I am happy with what I have."** People were reluctant to engage with novel technologies in their environment. To them, it seemed too abstract to have impact in their daily lives.
- **"I saw that in Star Trek."** In interviews we got often ideas which people took from popular science fiction movies or literature. As the technology did not seem real to them, they did not actually relate it to their everyday lives.

With technology probes we engaged people with a specific but concrete and tangible piece of technology. People try it out and see that this is real and even so it is a prototype, they can relate it to potential uses in their environments and in their everyday life. In our research we experienced that functioning prototypes engage people much more than paper prototypes or sole descriptions of technologies.

Beyond the technologies probes we gave a quick overview of potential further technologies for the home. They were encouraged to imagine what kind of information could be displayed and dynamically updated. Additionally we suggested that they should imagine applications if they had an extended number of such displays, 20 or more of any size, wirelessly connected, and embedded.

The overall approach provided us with many insights in how people deal with displays in their home environment. The presentation of physical prototypes, contextualized in possible scenarios of everyday life activities that we suggested (e.g. "when you wake up", "when you brush your teeth"), was particularly useful for generating design ideas and for understanding the user profile. People find it easier to relate to the task-oriented nature of scenarios: the combination of scenarios of everyday life and tangible previews of future technology proved to be a valuable method to stimulate their creativity. Using the technology probes people were less worried about technologies invading their homes and seemed to envision how to get hold of technology in a more personal way. It appeared that having a concrete example of technology reduced the fear of the unknown.

3. CONCLUSION

Based on the group we studied we concluded a number of design guidelines that can help to create novel display artefacts for domestic environments.

- **Embedding information where and when it is useful.**
- **Full Control but no Interaction required**
- **It matters how information is embedded**

It is central to provide the information so that the user can benefit from it. Most conventional displays we saw serve that purpose. Often the advantage of a display is minimal (e.g. it is only useful once a month). Usually information is embedded at points where decisions are made or where people have choices (e.g. at the key table when someone decides on the mode of transport). Making displays unobtrusive and matching the user' aesthetic values is a central advice. People would like to be in control of the technology they have in their environment, but they do not want to have the responsibility to interact. Implicit interaction, as suggested in [6], where the system reacts to what the user does in the real world can be a vision to achieve this.

4. ACKNOWLEDGMENTS

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