

Designing Ambient Computing for use in the Mobile Health Care Domain

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ABSTRACT

In this paper, we describe the Ambience Project, a project that aims, through ethnographic study of people in the work place, to identify and develop meaningful new ambient technology. Our research into ambient computing, with its aim of developing technology which blends naturally into the normal interactions and physical spaces of human work practice, necessarily focuses on understanding what takes place in the work environment. We have begun an ethnographic study of mobile healthcare workers, and intend to use this detailed study of nurses and their clients to generate a framework for understanding interactions at a broader level. This framework will lead to the design and implementation of ambient devices to assist nurses in the everyday work tasks.

Keywords

Ambient devices; Ethnography; User centered design

INTRODUCTION

In 1991 Mark Weiser created Sal's world to show us where ubiquitous computing can take us ...

Sal awakens; she smells coffee. A few minutes ago her alarm clock, alerted by her restless rolling before waking, had quietly asked, "Coffee?"

It continues further on ...

Sal looks out her windows at her neighbourhood ... she sees electronic trails that have been kept for her of her neighbours coming and going during the early morning.

What Weiser [4] was trying to do was give an example scenario about how ubiquitous computing may affect our lives in a positive and exciting way. And he gave many wonderful examples. But the truth is I'm a restless sleeper and am thoroughly sick of being woken at 1am by my

alarm clock asking me if I want coffee – give me back my 20th century alarm clock! And I didn't really want to know what my teenage son and the neighbor's daughter were getting up to first thing this morning!

The point being (if a little overstated) is that in order for ubiquitous computing to be all that we dream it will be, we need to be sure we are creating technology that users want to use, not just technology for technology's sake. This is not an issue that Weiser ignored. In a presentation to UIST'94 on building invisible interfaces, he emphasized starting from social science insights in a effort to radically reinvent technology to fit people in the aim of achieving "true human effectiveness" [5]. Streitz and his Ambience group at GMD-ISPI [3] also take a human-centered design perspective as they integrate social and technological approaches in order to determine requirements for ambient information support. This is what members of the DSTC Ambience Project are aiming to do, and in doing so address the issues raised by the workshop presenters.

THE AMBIENCE PROJECT

The ambience project aims to develop and implement ambient computing – distributed devices that blend naturally into the normal interactions and physical space of human work practice as they gather, integrate and display information that assists work. It has been largely motivated by work in the field of computer-augmented environments (see [7] for an overview). We aim to understand how to blend technology with human activity in order that the activity proceeds fluidly, unencumbered by having to focus on working the technology.

Ishii and Ullmer [2] suggest the use of ambient media such as sound, light, airflow, and water movement to act as background interfaces with cyberspace and work at the periphery of human perception. An early example of ambient computing was XEROX PARCs live wire [6] which hung in the corner of the room and oscillated at different frequencies depending upon the amount of local network traffic. In order to tell if the network was busy, a researcher needed only to catch the movement of the rope in the corner of his or her eye, rather than execute a specific

command. Current research is focusing on integrated ambient environments. A key design challenge is to understand what information to collect in which kinds of devices and how to integrate and distribute displays of information.

From a research perspective our key research challenges are:

- the development of strategies for determining the extent to which a user needs to be aware of the activities of others, and at what level of granularity and intrusiveness; and
- the exploration of integration of information and physical environments so that users have seamless, direct interaction with resources or each other without intrusion from the IT infrastructure.

Specifically, our aim is to develop a theoretical framework that characterizes possible human interactions in physical space and the types of information that are exchanged during these interactions. The framework will explore the continuum from highly task specific to generalisable interactions. It will explore how information is exchanged through interaction, ranging from tacit awareness information to specific articulated information. It will lead to an understanding of the quality of pleasing physical, spatial, tactile and visual interactions. This framework will promote an understanding of the characteristics, opportunities and limits for ambient information gathering and display technologies and assist in the identification of promising prototype opportunities.

In order to develop computing technologies that support the natural interactions of humans it is necessary to draw upon methodologies used to understand human activity that have been developed in the social sciences, anthropology and industrial design. It is thus necessary to undertake an iterative approach of observation, analysis, envisioning, design, deployment and evaluation (see Figure 1). This iterative approach will help researchers to develop a dialogue and move closer to understanding a complex problem space.

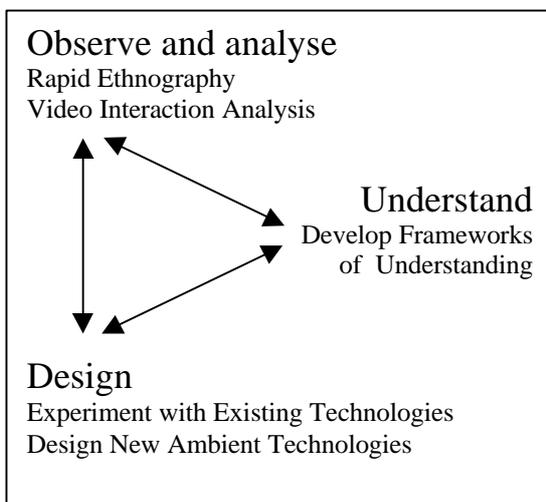


Figure 1: The observe-analyse-design cycle

The First Step: Observe and Analyze

The first step in the iterative process, is to conduct a detailed, in situ observation of a work environment. Because it is impossible to guess what people do with technology, what they really want in technology, or how they behave using technology, it is necessary to observe people doing tasks in their normal environment, and when assisted by technology. This process closely followed the principles of ethnography. Blomberg describes ethnography as it relates to human-computer interaction as the process of conducting field research with the aim of developing understandings of everyday work practices and technologies in use [1]. By following the core principles of ethnographic study [as described in 1], researchers are able to study activities in the natural settings in which they occur and develop detailed descriptions of the work experience. The result is a study of what the workers actually do, not simply the accounts workers give of the types of activities undertaken.

Through performing an ethnographic study of workers in a natural setting, it is possible to describe the actions they perform, the kinds of information they utilize and the potential for technology to assist with various tasks. In addition the researchers are able to analyze and hence understand the relationships between particular activities.

THE MOBILE COMMUNITY HEALTH CARE STUDY

In following the philosophy of seeking to understand how to blend technology with human activity, researchers at DSTC undertook an ethnographic study that involved the observation of mobile community health workers as they carry out their daily tasks. This research group spent time with a community health care organization that consists primarily of nurses who provide health care to people in their homes. This ethnographic study has been undertaken with the aim of providing a solid foundation for the design of appropriate technologies for workers in this organization. Consequently, we needed to understand more about how community health care happens 'on the ground'.

This study involved the use of rapid ethnographic techniques and included a collaborative analysis of focus group data collected by staff in the organization, and exposure to work carried out in the field. Three researchers followed nurses around in the field for a total of seven days. The focus group data was able to identify the initial feelings and thoughts of the nurses about the types of technology that they felt may be of use. The larger analysis of the ethnographic data produced mind maps that provide a detailed overview of the ideas, insights and interpretations generated as a result of the rapid ethnography.

The nurses observed are a skilled and multi-faceted group of mobile workers. From our initial study we have identified three different styles of interactions. Their day typically consists of work performed in the car, in the clients' homes and in a central office.

In the Office

In the office we found nurses were very much focused on information. They were required to complete documentation, write referrals, make telephone calls and prepare for the following days visits by gathering supplies and collating charts and other information. The nurses also spent time exchanging information with other nurses. Activities included skill mentoring, asking for advice and support, sharing information and debriefing.

In the Client's Home

In contrast, the home visits were very much client focused. We observed strong relationships between nurses and clients. The nurses were involved not only in the care of a patient's specific health needs (e.g. the bandaging of a wound) but also were involved in many peripheral activities. They used all senses to gather information – for example they checked the refrigerator for food and could easily tell if the client was able to bath and toilet themselves. The nurses performed many activities during the visit other than the primary reason for the visit.

In the Car

Apart from being a means of transportation, the car also served as a mobile office and supplies store, and a lunchroom. The nurses used the time traveling in the car in various ways: as time out, listening to the radio and singing along; thinking about the next client; and thinking about the previous client. Navigation is also an issue in the car as nurses made frequent use of street directories to decide the best route to the next location.

Ubiquitous Computing for Mobile Health Workers

Our question then is how do we design ubiquitous computing solutions for all three styles of interactions. Given the initial study there are many factors that need to be taken into consideration. The rapid ethnography, while only spanning 2 months in total, was vital in identifying the specialized needs of these mobile health workers and their clients. The *main aim* of this study has been to gain a richer understanding of the communication and information sharing work involved in community nursing. These insights will help inform the design of technologies that will fit into how work really happens "on the ground", not just as described in procedure and policy manuals. As the study focused on nurses in their work environment and looked at both technologies and work practices, we have gained some understanding of the extent to which the nurses interact with information, the types of interactions occurring, and the ways in which new technology could assist in this interaction.

STAGE TWO – DEVELOPING FRAMEWORKS FOR UNDERSTANDING

The movement from ethnographic study to the design of new technologies is complex [1]. The difficulty – which is particularly relevant to the Ambience project – relates to how the descriptions generated by an ethnographic study are able to inform the design of a device. Here a short-term aim of the Ambience project is to develop a framework that

will simplify this process. This is the focus of the second stage of our study which is currently underway.

This stage of the process involves a more detailed analysis of the nurses in their work place. In particular, we are going in to the field to discover the specific ways in which nurses interact with objects and tools and each other and the types of information contained in these interactions. Our aim is to produce a detailed framework that will guide the development of new, or appropriate implementation of existing, technologies.

Video Analysis

The data collected in the initial study with mobile health workers included field notes, digital photographs, artifacts and interviews. Video recordings will augment this type of data collection in the second stage analysis. We believe that video footage of work carried out by the nurses will enable us to better access the richness and complexity of their daily interactions. Given the ability of video to be repeatedly scrutinized and inspected in great detail we hope to identify and analyze the real world actions, activities and events in which the nurses participate.

It is this "microscopic" study of the mobile health workers that will provide us with the beginnings of a framework for understanding the characteristics of the interactions in the physical space and the types of information that are exchanged during these interactions.

To assist us in this task we will introduce a number of technological solutions that presented themselves as possibilities after the completion of the first stage of observational analysis. By inserting technology into the activity and observing, it is possible to understand how the technology is used and how it changes the activity.

For example, we noted on many occasions difficulties related to the use of synchronous communications methods. In many instances it was difficult for nurses to contact other health care practitioners and related community agencies via the telephone. It has been noted that an asynchronous communication method such as email or buffered messaging, with appropriate feedback mechanisms, is a lightweight solution that is likely to offer significant benefits. These methods have not yet been deployed in the environments observed. In order to verify this assumption, and many others that we produced as outcomes of the initial study, it would be useful to implement this technology and observe it in use.

While email could not be described as an ambient technology (indeed it could be considered a rather mundane technological solution), once we have established that email is a viable and improved method for nurses to communicate with other healthcare practitioners, further ambient-based research and development would then be undertaken.

MOVING TO DESIGN

While the mobile health care worker project has yet to move into the device/service design phase there have been many ideas stemming from the initial ethnographic study.

Given the example from the previous section, an interesting project would involve developing a novel way to provide nurses with asynchronous communication technology. Ambience researchers would focus on providing them with a service which is novel in its design, which considers the nurses particular needs, and minimizes the intrusion of this new technology into their work environment. It is the aim of the Ambience project to firstly understand how this everyday work task of contacting other healthcare professionals can be better supported by new technology and, secondly, how this task can be changed for the better through the use of ambient technology. In this example we would endeavor to make the technology involved in an email task transparent, ensuring that the user doesn't need to think about the user interface, but rather can focus on the message that needs to be conveyed. To achieve such a goal, we would need to work towards identifying important contextual issues – when the nurses need email facilities (would they be in the car, in the clients home, in the office, or any combination of these three), how particular environments would effect the task, and what style of interaction is most appropriate.

To provide another example, the study identified that nurses, while taking the need for good client care very seriously, were finding work increasingly stressful, with more driving, and more administration and paperwork.

An ambient computing solution, inspired by Weiser's vision of a window containing electronic trails and time markers, and made possible by tiny, inexpensive, networked sensors, may be a viable solution. While we used this particular example in the introduction of this paper to raise issues about usability and user-centered design, our observations of mobile health workers and their clients' has lead us to believe that such technology may indeed be very useful. The important point to stress is that, through a rapid ethnographic study, we have *matched* a potential solution to the environment and the people involved.

By embedding many sensors into a client's home, mobile health workers would effortlessly be about to gather valuable information about the health of a client in very little time without having to visit them.

They could easily assess the mobility level of the client, whether the client bathes and eats regularly, to what extent the client has interactions with others and whether a client is regularly taking medication. It could also provide an alarm trigger if there was an extended period of inactivity. This type of technology would be non-invasive for the clients, who in many cases would not be able to use the assistance provided by other advances in technology such as video conferencing¹. While this type of technology would not replace the much-needed physical contact between nurse and client, it would provide an additional level of care which would otherwise be difficult to maintain. We will explore this idea further in conjunction with the nurses and their clients.

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¹ Many clients suffer from dementia and would struggle to work new technological devices

