M O B I L E A W A R E N E S S

Master of Science Thesis,
Department of Informatics, Göteborg University

PLAY research group, Viktoria Institute

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Jennica Falk
jennica@viktoria.informatics.gu.se

Mentor: Lars Erik Holmquist
leh@viktoria.informatics.gu.se

Abstrakt - Abstract in Swedish

Medvetenhet är till stor hjälp för att dels förstå andras aktiviteter och dels för att sätta sina egna aktiviter i sitt sammanhang. Till exempel bidrar medvetenhet om varandas närvaro, eller frånvaro, med viktig information till människor som arbetar tillsammans. Då majoriteten av dagens “awareness” (medvetenhet) applikationer är stationära och dedikerade till sådana uppgifter människor förväntas utföra vid sina skrivbord, är de inte tillräckliga i mobila situationer. I denna magisteruppsats lägger vi fram ett förslag på hur vi skall lösa detta problem. *Hur kan vi, med hjälp av informations-teknologi, erbjuda mobila användare awareness-stöd?* Inspirerade av existerande ideer och applikationer, har vi kunnat utläsa design-implikationer för en ny ansats till mobilt awareness-stöd. Vi presenterar vårt *Interpersonal Awareness Device* (IPAD) koncept som innefattar IT-produkter som har som uppgift att stärka awareness mellan människor i mobila situationer.

För att utforska IPAD konceptet konstruerade vi en prototyp, en s.k. *Hummingbird*, som är en liten bärbar anordning framtagen för att stödja gruppmedlemmars närvarokänsla i en fysisk miljö. Detta ställde oss inför utmaningar i både konceptuella såväl som fysiska design-frågor. Vår metodansats omfattades av prototyping som gav oss utrymme att modellera och utvärdera våra ideer under hela utvecklingsprocessen.

Utgångspunkten i våra användartester var att använda Hummingbirds i olika verkliga situationer och studera vilken effekt de kan ha på en grupp. Resultaten visade att de på ett effektivt sätt bidrar till gruppmedlemmars känsla av tillhörighet, men också att de användes på olika sätt beroende på vilken miljö de användes i.

Abstract

Awareness is a significant aid in understanding the activities of others, as well as creating a context of ones own activities. For example, being aware of each other's presence, or absence, provides important information for people who work together in collaboration. As the majority of awareness applications of today are stationary and dedicated to the tasks people are assumed to conduct at their desks, they are insufficient in mobile situations. In this thesis, we propose one solution to the problem: *How can we, through information technology, provide awareness support for mobile users?* Inspired by existing ideas and applications, we have drawn design implications for a novel approach to mobile awareness support. We propose the *Interpersonal Awareness Device* (IPAD) concept, which accommodates a class of information technology devices with the aim to strengthen awareness between people in a mobile setting.

To explore the IPAD concept, we constructed a prototype, the *Hummingbird*. This is a small portable device designed to support awareness of presence between group members frequenting the same physical space. In doing this, we faced challenges in both conceptual and physical design issues. Our method incorporated a prototyping approach, allowing us to model our ideas and perform hands-on evaluations of their validity during the entire development process.

When we performed user evaluations of the Hummingbirds, the objective was to incorporate them into various real-life situations and study how they affect groups. Our results clearly show that they effectively contribute to the group members' awareness of each other, but also that they were used differently depending on the setting they were used in.

1.0 Preface

The work with this thesis was conducted within the *Mobile Informatics* program at the Viktoria Institute. Mobile Informatics is a joint industry and academic research program funded by SITI, the Swedish Research Institute for Information Technology, and coordinated by the Viktoria Institute in Göteborg. The overall objective of the program is defined as *innovation of new IT use in mobile settings* (Dahlbom et al., 1998). One of the three main domains of exploration in the program is called *Mobile media and entertainment* and serves as a particular framework for this thesis. The design, development, and evaluation of innovative media in the context of mobility and entertainment constitute the main objective. The research should result in creations people both can and want to use. Quoting from the research program written by Dahlbom et al. (1998), Mobile media and entertainment is described as follows:

> "*This project will focus on researching the human-computer interaction (HCI) aspects of mobile applications. We will accomplish this by developing working prototypes that demonstrate various research innovations, and then evaluating those prototypes. In doing this, we will focus on development first, and user evaluation second.*"

One project in the Mobile media and entertainment domain is the Inter-personal Awareness Device (IPAD) project, aiming to make innovative contributions to the area of interpersonal technology. This thesis is one of the results from the work within the IPAD project where important results are the development of the Hummingbird prototype and the conceptual elaborations on interpersonal technological devices that support group awareness.

1.1 Acknowledgments

I am particularly grateful to **Lars Erik Holmquist**, initiator and leader of the PLAY research group and the IPAD project at Viktoria Institute. He has been very patient and very helpful throughout the work with this thesis. I am also very grateful to **Joakim Wigström**, my colleague in the IPAD project. Without him - there would be no prototype. I also must express my gratitude to all the test-users: **Charlotte Averman**, **Staffan Björk**, **Roberto Busso**, **Peter Ljungstrand**, **Johan Redström**, **Ella Tallyn**, **Karl-Petter Åkesson**, and to everyone else who have offered insightful comments and ideas for our work.

Special thanks to **Antonio Cordella**, for being encouraging in times when I lacked focus and structure in my work. And of course, **Staffan Björk**, who has been very supportive and really helped a lot in reviewing the text itself. Thanks also to **Jona Bjur** and **Gunilla Grahn** for design ideas for future Hummingbirds.

2.0 Introduction

People are on the move, both at work and otherwise. At most workplaces today, people face situations in which they must be *mobile* in carrying out their tasks (Ljungberg, 1997). In essence, this means that people leave their desks and their offices to perform tasks at other places. In addition to being mobile, people still have colleagues with who they must collaborate to an increasing extent. In *collaborative work*, i.e. when people make a joint effort to carry through work tasks, communication is of course an important aspect as colleagues need to plan and update each other on the ongoing activities. It has been argued that *informal communication*, i.e. spontaneous and face-to-face interactions is a very important requirement for work to be effectively carried out (Whittaker et al., 1994). It is therefore important to be *aware* of other people, their whereabouts, and their activities.

The objective of this thesis is to introduce and describe a new mobile computing device to be used by members of a dispersed group who frequent the same physical locations. As the device propose a novel way to support and strengthen awareness between group members, discussions about issues such as awareness, mobility and collaboration lead up to the conceptual model instantiated by the device.

In the following sections we describe the research background, the academic framework for our study and an articulation of the research scope. In the remainder of the thesis, we describe the method and the conceptual work which make out the foundation for the prototype we have developed. Further, we describe the prototype evaluation process and the conclusions made. Some ideas for the future are also presented.

2.1 Research Background

Awareness is a term expressing consciousness, or watchfulness in observing. This consciousness is by human nature limited by our senses and our capacity to perceive and process impressions when experiencing the world. In a work setting this may have implications on the ability to be aware of on-going activities in places separated from one’s own. It is easy to see how it may negatively affect the capabilities to collaborate and be effective as a group when people are not in touch with the activities of others.

These problems are relevant for the field of CSCW (Computer Supported Cooperative Work). Researchers in this field attempt to bridge the awareness-gap between people in distributed work situations by facilitating various awareness-promoting systems by ways of information technology.

Awareness is a fairly general term, perceived and used differently in different CSCW situations. To give some illustrating examples of how the term has been

used, consider the following suggestions offered by researchers in the CSCW community:

- *Informal awareness* provides a general feel for who are present and what they are doing in a surrounding. This type of awareness plays an important role as "*social glue*" and promoter of spontaneous interactions between people (Greenberg, 1996).
- A similar definition of awareness is that it "*involves knowing who is 'around', what activities are occurring, who is talking with whom; it provides a view of one another in the daily work environments*" (Dourish & Bly, 1992).
- *Workspace awareness* (Gutwin & Greenberg, 1996) involves understanding others' interaction within a shared workspace. To provide an example, WYSIWIS (What You See Is What I See) systems (Stefik et al., 1987) provide users with a view into the location and focus of attention of others in a multi-user or groupware system.

In addition to recognizing the importance of various kinds of awareness, the CSCW field has conducted several studies on how to provide technological and IT-based means to support awareness in various organizational situations (Dourish & Bly, 1992; Gutwin & Greenberg, 1996; Gutwin et al., 1996; Tollmar et al., 1996). Awareness is currently a much discussed issue in the CSCW community (Crow et al., 1997), widely recognized as an important factor to consider in collaborative work (Tollmar et al., 1996).

Several of the ideas in this area have resulted in the development of systems designed to support collaboration between groups of people. The more conventional ones, such as video-conferencing systems, and internet-phone applications, allow users to have visible and audible contact with each other. Examples of slightly more unorthodox implementations are the *Portholes* (Dourish & Bly, 1992), the subsequent release *NYNEX Portholes* (Lee, 1997), and *@Work* (Tollmar et al., 1996), which provide users with a video-based view of others availability and activities. *Peepholes* (Greenberg, 1996) is a system similar to Portholes but provides users with iconic presence indications rather than video-based such. In *TeamRooms* (Roseman & Greenberg, 1996) users share a virtual room in which they can collaborate with each other. Aspects of both real-time and asynchronous groupware combine into a "network place" which serves as a room, or locale for collaboration.

Not all implementations utilize video- or image-based techniques to convey awareness information. The *ICQ* application (Mirabilis) is a system that notifies its user of which of their contacts are on-line or not. The application has over 19 million registered users, an indication of peoples' interest in keeping in touch with each other. ICQ will be described in further detail below.

Most of the studies on collaborative work, and most of the existing ideas and technologies developed to support collaborative work, are dedicated to the tasks people are assumed to conduct at their desks. At the same time, many studies indicate that people are rarely at their desks. *Mobility at work*, i.e. moving around to perform tasks, or in pursuit of resources or other people, is currently an increasingly important part of the work situation (Bellotti & Bly, 1996; Luff & Heath, 1998).

Mobility at work has also been described to have the effect of increasing *informal communication* and collaboration locally (Bellotti & Bly, 1996). Informal communication can be described as communication that arises without planning. Whittaker et al. (1994) characterized informal communication as being *brief*, *unplanned* and *frequent*, taking place *synchronously* in *face-to-face* settings, a description that indicates high relevance in physical proximity. Informal communication is recognized as an important aspect of work, supporting a number of work-related tasks such as group coordination, team building, socialization, and information exchange (Whittaker et al., 1994).

An example of a system that takes into account that people are actually moving about is the *Active Badge* system (Hopper et al., 1993; Harter et al., 1994). It is a locating system that keeps track of the physical whereabouts of people and inventory. Co-workers trying to locate their locally mobile colleagues may for example use the location information generated by the system. A commercial product that has been very successful is the *Lovegety* (Iwatani, 1998). This palm-sized device, designed to be carried around, beeps when it comes near another Lovegety with a matching configuration. This Japanese product sold in record numbers within months of its introduction on the market in 1998.

To clarify the picture we are trying to paint here; awareness is an important factor in collaborative work, but the greater number of applications and ideas on how to increase awareness assume that users spend the majority of their time at their desks or in front of a computer. We are dissatisfied with the immobility of these technologies. What we would like to explore is how awareness support can be made mobile.

The importance of awareness for collaboration, and the increasing mobility of people, have served as inspiration and focal point in working with this thesis. The problem is that the majority of the available awareness support systems are developed for situations where people are assumed to be stationary. As people are leaving their desktops, they need alternative awareness support to effectively collaborate when mobile. This serving as food for thought, a process of thinking of novel ways to support awareness commenced. We formulated the problem for this thesis to focus on to be the following:

How can we, through information technology, provide awareness support for mobile users?

2.2 Academic background

As students of *Göteborg Informatics*, we feel it important to find a framework for the thesis within this research approach. Dahlbom (1995) defines Göteborg Informatics as "*a design oriented study of information technology use with the intention to contribute to the development of both the use and the technology itself*," with its focal point in the "*information technology use*." (Dahlbom, 1995).

Dahlbom stated "*... we should remain engineers with a design orientation, with an interest... in local design principles rather than general laws,... in heuristics and innovations rather than methods and proofs, in the good and beautiful rather than the true*" (Dahlbom, 1995). Studying the use of information technology with the intentions as defined by Göteborg Informatics, we must have a future oriented approach in order to "*contribute to [development]... rather than just observe and describe...,*" (Dahlbom, 1995) innovations in information technology.

In describing the Göteborg Informatics research approach, we attempt to highlight our ambition with this thesis; to contribute to the development and use of information technology by utilizing the *existing* in order to create the *innovative*. We believe that the answer to our research question - "*How can we, through information technology, provide awareness support for mobile users?*" will have an obvious place within the Göteborg Informatics approach.

2.3 Delimitation of Scope

So far we have been discussing terms like mobility and awareness in a somewhat general context. It is necessary to go beyond the general to narrow, as well as define our scope in order to make the study meaningful.

Awareness is a central term throughout the entire thesis. In the light of the various definitions of this term our focus will be on what we call *group awareness of presence*. By awareness of presence we mean the awareness of another person's presence as well as your own presence in an environment. Further, group awareness of presence we define as group members' mutual awareness of each other's presence.

In the context of our work, presence will imply physical proximity. Hence, to be present can be described as the state of being '*at hand*', or '*within sight*' in a physical environment. It is a common sense definition of the word, indicating a state of physically being in the place in question. In contrast to this view, consider telepresence, which has been described as the experience of presence by means of a communication medium (Lombard & Ditton, 1997), suggesting a state of presence in a remote environment. Lombard and Ditton have also stated

that telepresence media should aim to provide users with an illusion of non-mediation; a suspension-of-disbelief that they are not in an environment separate from where their real bodies are located. The concept of telepresence goes beyond the scope of this thesis, since we in fact want to focus on groups of people who frequent the same physical location.

The term group will be used often in this thesis and should therefore be anchored in a theoretical context. According to Schein (1980), a group consists of two or more persons who 1) interact with one another, 2) are psychologically aware of one another, and 3) perceive themselves to constitute a group.

Groups are often defined in terms of their members. For example, Napier and Gershenfeld (1989) stated that in a group 1) membership is defined, that it is clear who is a member and who is not, 2) members think of themselves as composing a group, that they have a shared identity, and 3) members share a common reason for being in the group. Other theorists have stressed the dynamic interdependence between the members of a group. Forsyth (1990) studied group behavior and group dynamics, and has therefore defined a group to be a constellation in which two or more individuals influence one another through interaction.

We summarize the definitions by suggesting that there are two central dimensions of a group. In one aspect it is a social construction to which we may or may not belong, and in the other aspect it is an interactive construction in which we carry out actions in line with a common purpose. In conclusion, when narrowing our scope to group awareness of presence we are really concerned with the awareness between people who are in the same physical proximity and who already constitute a group.

As with awareness, mobility is a central term in this thesis. Mobility in its general meaning defines a state of being mobile which in turn implies not being confined to a fixed position, to be movable. In the field of CSCW, being mobile indicates a state of being able to perform work at any given place, to not depend on a specific place to conduct work. The type of mobility we are concerned with in this thesis, *local mobility*, is described by Bellotti and Bly (1996) to occur in situations where people do not move too far away from a given local point; e.g. moving between offices or buildings at a local site. Groups that more move across and between locations, with internally mobile members, are what we are interested in. Such a group might for example be a group of colleagues travelling to a conference together.

In the field of classical Informatics, *information* is an essential term. Langefors holds one of the prevailing definitions of the term; *Information is knowledge*. From his infological equation, it follows that information is the subjective interpretation of data, the result of mental activities, knowledge (Dahlbom, 1993). Dahlbom and Mathiassen have not been quite as mathematical in their defini-

tion, but defined information in a similar fashion - as something which is somehow related to knowledge (Dahlbom & Mathiassen, 1993). They have stated that information is something that helps us understand, make decisions, or act. Langefors' definition, as well as Dahlbom and Mathiassen's, refer to information as something with a core that is subjective and personal. While these definitions may be sound, they are not sufficient in the context of our work. We have therefore generalized the meaning of the term and assigned it a functional significance, as something that satisfy a certain information need, something that answers questions or explains what we are not certain of. By this definition, a watch or a thermometer are information systems as much as computers are.

In this thesis, we describe the work with an information providing device, and when we say that this device conveys presence information, what we really mean is that it answers a particular question; who is present?

3.0 Method

In this section we will describe the strategy used in the quest to find an answer to our research question. The problem we were facing, to provide information technology based awareness support for mobile users, imposed both conceptual and physical design challenges. We started out from existing technology and applications to find inspiration for an innovative design. When wanting to utilize the *existing* in order to create the *innovative*, it is reasonable to first conduct a thorough *examination* of the existing. Thus, with the analyzed material as a starting point, we could begin to outline a conceptual model of mobile awareness support technology. To explore this conceptual model, a proof-of-concept was developed and evaluated.

3.1 Literature review: examining the existing

Prior to drawing design implications and setting functionality requirements of a prototype, we saw it necessary to paint a picture of the current research on awareness and collaboration. Naturally, it is important that the information we used as basis for reasoning and assumptions was approved by research communities. Therefore, we used the ACM[1] digital library where journals and proceedings from major conferences are filed. Much time was spent simply browsing the library, searching for papers containing keywords such as ‘awareness’, ‘presence’, ‘collaboration’, ‘mobility’, ‘informal communication’, etc. Studying the reference lists in the papers was found to be an especially useful method to locate additional publications that were not easily found with other methods.

Although conference proceedings account for the bulk of the accumulated information sources in our case, various books on human-computer interaction, organizational psychology, design methodologies, and CSCW have also come in handy. We have used the University library in search for published resources not found on the World Wide Web.

1. ACM, the Association for Computing Machinery, is an international scientific and educational organization dedicated to advancing the arts, sciences, and applications of information technology. ACM publishes, distributes, and archives original research and firsthand perspectives from the world’s leading thinkers in computing and information technologies.
(http://www.acm.org).

3.2 Prototyping: creating the innovative

The method we have used in the development of our prototype[1] is appropriately called *prototyping*. The prototyping procedure is a stepwise development process of a product[2], with feedback sessions taking place in-between the steps. The purpose of the feedback sessions is to evaluate and suggest improvements for the next-generation prototype. The entire prototyping process is consequently a process that begins with an idea or a need for a product, and ends with a finished product ready to be used (Lundequist, 1995, Swedish reference.). Figure 1 shows the general framework of the prototyping method:

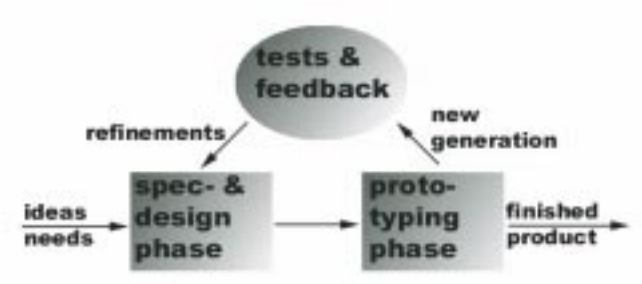

FIGURE 1. The prototyping method. Ideas take the form of specifications that are implemented in a design-model. The model is evaluated and refinements are suggested, and the iteration starts over again

The prototyping method can be viewed as an approach that allows for an integration of the physical- and the conceptual design. Ideas and needs that are not perfected can still be explored and evaluated as they are taking their final form. (Gibson & Hughes, 1994). Common techniques involve *evolutionary prototyping* and *rapid prototyping*, two techniques that are very similar in their approach to product development; both provide an explorative process where ideas can thrive and evolve:

- Evolutionary prototyping is based on the idea of developing an initial, incomplete, implementation, expose it to critical review, and refining this through many versions until the desired product has been developed (Som-

1. The word prototype is derived from the Greek word *protos*, meaning first, and *typos*, meaning form or archetype - the model for all other specimens of its type. So in essence, a prototype is an approximation of a type that exhibits all the essential features of a final version of that type (Avison & Fitzgerald, 1995).

2. By product we mean a result in general. It may be an idea, a proof-of-concept as in our case, or a product ready for a market, etc.

merville, 1996). This technique takes the *well-understood requirements* of a systems specification as a starting-point and proceeds from there to those requirements which are unclear. Sommerville stated that evolutionary prototyping therefore is one methodology that tackles the difficulty of vague or unclear systems requirements.

- Rapid prototyping is a design methodology that quickly develops new designs, evaluates those designs and then discards them after each prototype-design phase. Sometimes this methodology is referred to as "throw-away" prototyping (Sommerville, 1996). This technique, in contrast to the evolutionary prototyping technique, focus on the requirements in the specification which are *unclear* and not well-understood. The objective is, according to Sommerville, to discover flaws and the best possible solutions to realize the systems requirements.

3.2.1 A contrasting development approach

When we were initially facing the problem of choosing a method we also considered the one most commonly used. This is a traditional development technique called the "waterfall" method. It was named so because it is built-up by several stages, each following the other in succession like a waterfall. Each step is initiated only after the preceding one is achieved. At each stage the results of the previous stage are said to flow down and there is no turning back once each step is completed. (Sommerville, 1996). Figure 2 depicts the general structure of the method:

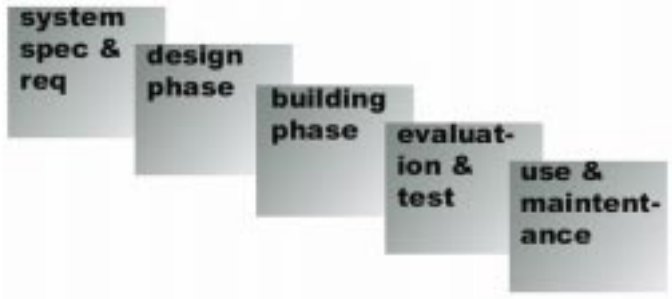

FIGURE 2. The sequence of steps in the "waterfall" method. Once each stage is completed, the results "flow" down to the next stage and the next step begins

A significant problem with the waterfall method is that it does not accommodate additions and refinements to the system specification during implementation. If a new system requirement is determined in the testing phase it is too late in the

process to incorporate this new requirement. This suggests that for the method to be really useful in a development process the development team must know everything it needs to know to finish the product at the start of the process. The method is therefore best suited for well-defined and well-structured tasks.

3.2.2 Why prototyping?

Since we wanted to do both conceptual and physical work, it made sense to use the prototyping method. In the beginning of our study we did not have very clear specifications of either the concept or of the prototype we were going to build. Therefore, an approach such as the “waterfall” method would obviously be inappropriate. The prototyping technique on the other hand, is recognized as particularly suitable in situations where specifications are unclear or not very articulated (Gibson & Hughes, 1994). The prototyping approach allowed us to model our ideas and perform hands-on evaluations of their validity, and the approach also provides a framework for the development and evaluation of new ideas, conceptual as well as physical, that arise during design activities.

Using the evolutionary and rapid prototyping techniques in combination provided a good framework for our study. The rapid prototyping technique was especially suitable early in the design process, when building the physical representation of the concept, i.e. the prototype hardware. Since we initially were not certain how to design the hardware, the technique allowed us to experiment with various designs until we found one that had the intended form and function. The evolutionary prototyping technique was useful when the hardware platform was completed as we could move on to elaborate on software issues. Taking the well-understood function requirements of the prototype as a starting point, and implementing them, the remaining software functions could be explored and refined.

4.0 Related work

We have mentioned awareness as an important issue in the CSCW community. We have also argued the importance of informal communication. To get a clearer taxonomy, however not complete, of contributions in the field of awareness support, we have found it convenient to provide a section where we describe related work and implementations that inspired in both the conceptual work, and in the prototyping phase.

4.1 Calm technology

The majority of information technology is rather “loud”, overwhelming, and demanding for our attention. Ringing telephones, buzzing beepers, blinking and beeping computers, television sets, and so on are some examples of technologies that most of the time produce an overload of information and “attention grabbers”.

The notion of *calm technology*, presented by Weiser and Brown (1996) is that of technology that is both *informative* and *encalming*. In the world of calm technology, computers enhance our lives and make tasks easier, but without causing stress.

> “*Calm technology engages both the center and the periphery of our attention, and in fact moves back and forth between the two. We use “periphery” to name what we are attuned to without attending to explicitly.*” (Weiser & Brown, 1996).

Inner-office windows are frequently used as analogous examples of calm technology. These windows extend our peripheral attention by creating a two-way channel for clues about the environment. Motion on the other side of the window triggers the move of attention from the periphery to the center, for example when a person is passing by on the other side. In contrast to the inner-office window, picture a open office plan where workplaces are not separated by walls. Movement in this environment, argued by Weiser and Brown, is much more intrusive and center-focusing.

An example of a calm technology appliance is the *Dangling String* (Weiser & Brown, 1996). It is a long plastic rope connected to a motor that in turn is connected to a network. The rope is hanging from the ceiling in an office. The connection to a computer network causes the motor to twitch when data passes through the network wiring. As network traffic increase and decrease the rope “responds” by waving faster or slower in the air. This movement of the rope triggers the move of attention from the periphery to the center.

Weiser and Brown has argued that with calm technology it is possible to become attuned to more perceptual information. This is explained by our capability to place and process more things in the periphery than we can in the center of attention:

> "*Things in the periphery are attuned to by the large portion of our brains devoted to peripheral (sensory) processing. Thus the periphery is informing without overburdening*." (Weiser & Brown, 1996).

Buxton's model regarding background and foreground modes of communicative activities incorporate ideas similar to those of calm technology (Buxton, 1995). Foreground activities take place in the center of human consciousness and are intentional activities, such as talking on the telephone or typing on a keyboard. Background activities take place in the periphery of attention and include for example being aware of someone in the corridor, or an unusual sound coming from the engine of the car you are driving. Given this argumentation, we are convinced that the idea of calm technology is not only applicable, but also an enhancement, to awareness technology.

4.2 Examples of existing technology

Below, examples of implementations are described, from which we have found inspiration of various degree.

4.2.1 ICQ - I Seek You

ICQ (Mirabilis) is a client-server software application with the overall function to inform its users who of their friends and associates are on-line and who are not. The users list other ICQ users they want the system to 'keep track of'. When the client program is launched, it connects to a server and the user is signed on. The client software displays the listed contacts in a window, indicating whether they are signed on or not. When a user sign on, the server, that knows about the listed contacts of each user, will broadcast to the relevant clients who signed on. Everyone else on the list appears as off-line.

Running as a background application, it allows for users to concentrate on other tasks. A quick glance at the ICQ window is sufficient to tell who is on-line, providing the users with availability information. Icons provide additional information about the activity status of each user, such as if they are idle, away, not available, or occupied.

When bringing up ICQ as an example from which we can draw design implications, we are primarily interested in its function as an awareness information distributor. Its main strength is in its ability to function as an initiator of communication and coordination between people. Another strength with ICQ that we seek to exploit, is the way it can be placed in the background of attention. In a

sense it can be compared to an inner-office window that is placed on the desktop of a computer. Less interesting in the context of the work with this thesis, are the features enabling ICQ users to send messages and files to each other. As ICQ is primarily used for message passing and simple dialogues, the application is a communications tool in addition to being an awareness provider.

Although there are versions of ICQ for mobile devices, such as PalmPilots and Windows CE devices, the application is still dependent on the server. For ICQ to be functional, the user must be signed on. Consequently, the majority of ICQ users run the application on their stationary computer.

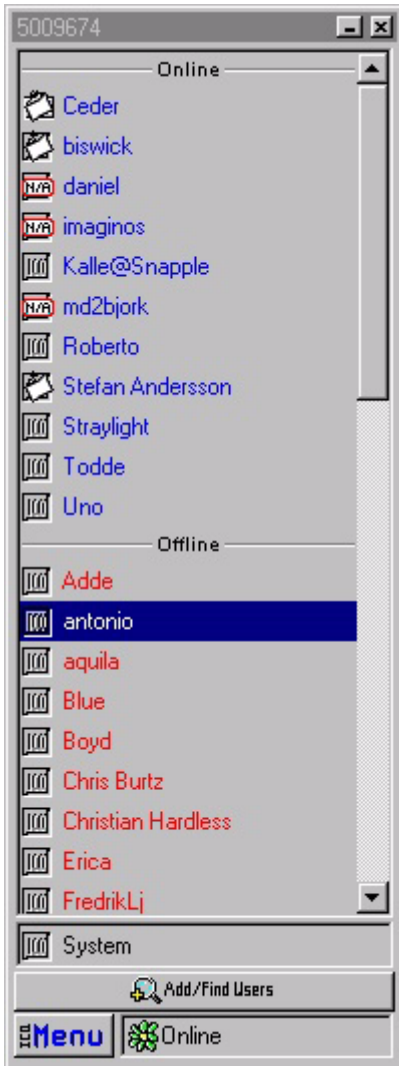

FIGURE 3. The ICQ client application. The listed contacts appear as either off-line or on-line

4.2.2 Lovegety

The Lovegety (Iwatani, 1998) is a palm-sized electronic device equipped with a radio transceiver that sends out signals and listens for other Lovegetys. They come in two colors - pink for girls and white for boys. There are three user-selectable settings - “talk”, “karaoke”, and “get2” and when two differently colored Lovegetys on the same setting are close, an indication is given in form of a beep and a flashing light. The range of the transceiver is sufficiently short, 4.5 meters (15 feet), and the users therefore have a good chance of spotting each other.

FIGURE 4. The Lovegety. When two differently colored Lovegetys with matching configurations are close to each other, they beep

When the Lovegety was introduced on the market in the spring of 1998 it turned out to be a huge commercial success, selling in record numbers (Iwatani, 1998), again an intriguing indication that this type of technology is attractive to people. The popularity of the Lovegety provides us with evidence that people are willing to, and interested in increasing their awareness of other people in their immediate surrounding. A second strength of the Lovegety is that it is a self-contained, mobile device. It does not depend on external infrastructure, such as sensors, centralized servers or the like, making it possible to be used anywhere and any time. All functionality is contained within the devices.

As its name and function imply, the Lovegety is meant to serve as a matchmaker between males and females on the same wavelength of interest, the same settings. It is therefore not designed to maintain a group constellation, but rather to create new one-to-one relations and to “introduce” strangers to each other. The Lovegety has one significant weakness in how it communicates the presence of another Lovegety. Both the tone signal and the flashing light are very ‘loud’ and attention demanding.

4.2.3 Portholes

The Portholes system (Dourish and Bly, 1992) is a desktop-based application, utilizing video technology to convey awareness and presence information. The application periodically takes video-camera snapshots of an environment and communicates these images to a centralized server where they are placed in a database of images. Using an image browser, subscribers of the Portholes service may access the database via their Portholes viewers. The viewer displays the most recent snapshots taken in the environments the subscriber is interested in.

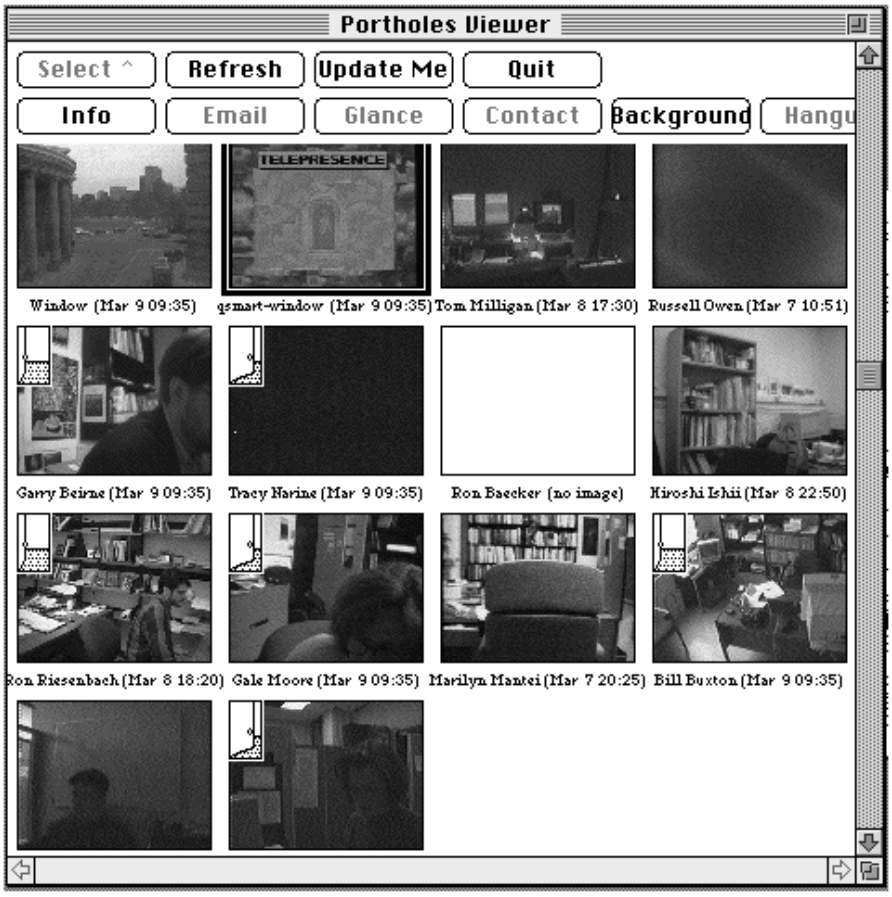

FIGURE 5. The Portholes viewer. Users can subscribe to snapshots taken by various cameras located throughout an environment. In this way they are able to determine the activities in surroundings other than their own

The idea is to extend the users awareness outside the physical environment and support awareness for distributed groups of people. Through the Portholes, users can see into remote rooms, for example a colleague's office, enabling them to determine who is there and often also what they are doing.

Like the ICQ system, Portholes is a client-server system. Cameras can be placed in various locations of interest, such as offices, coffee rooms, meeting rooms and so on. Users then subscribe to images taken by cameras in these places. The client software runs at the personal computer and will update automatically as the central image database changes.

The system is inspiring because it augments the physical environment of the users, enabling them to literally see through walls and around corners. The users awareness of the whereabouts of others is enhanced. However, we see a weakness with Portholes in that it does not support mobile users. The system will only provide awareness of presence information between people in front of a camera, and the cameras are static in the system. The users' presence is not broadcasted unless their pictures were taken. In addition, the client software is desktop-bound, so subscribers need to be in front of a computer to access the information.

4.2.4 Active Badge

The *Active Badge* (Harter & Hopper, 1993; Hopper et. al., 1993; Want et al., 1992;) system is a locating system that provides continuous location information about its users. The user wears, or carries, a small clip-on badge that has the function of a trackable tag. The badge is equipped with an infrared transmitter that emits a unique code in short intervals. The signals are received by nearby sensors which register the signal with a central service. The information is then processed and the user's location can be determined and made available on large display panels.

The desired effect of this system has been argued to be a more efficient coordination of staff in large organizations (Want et al., 1992). The first application, intended to demonstrate the system, was an installation to aid telephone receptionist. In this case the system provided a table of user names, their location, and the telephone extension nearest to them. The receptionist used the system when forwarding calls from the main switchboard, by looking at the display and redirect the calls to the correct location.

The obvious inspiration is drawn from the fact that, like the Portholes, the Active Badge system has the capability to augment the physical environment of its users. Moreover, it is mobile. However, the components are not self-contained units, but dependent on each other. For example, the Badges need an infrastructure with sensors and servers to process availability information. When a badge is taken out of this infrastructure it ceases to function. In essence

this means that the system is contained within the boundaries of the installation, and only as mobile as that.

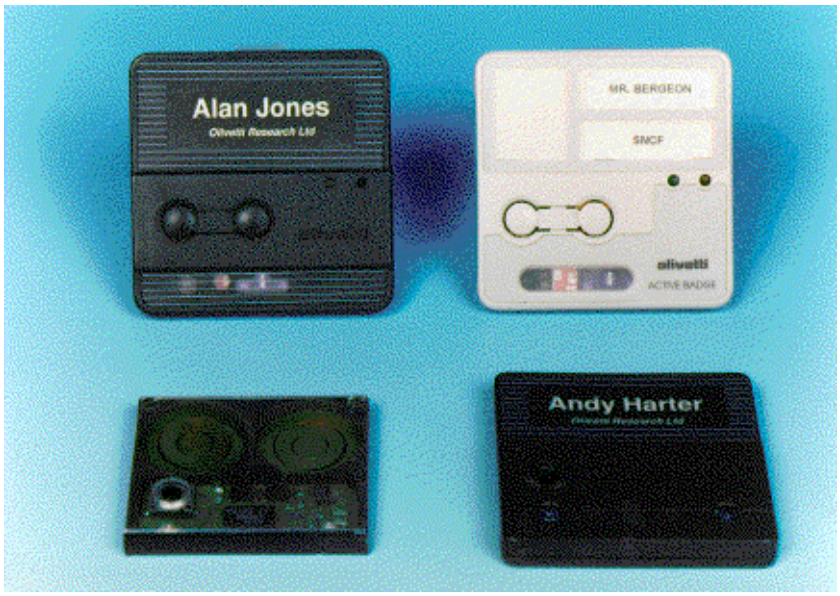

FIGURE 6. The Active Badge system. Wearable, personal clip-on badges emit trackable infrared signals

5.0 The IPAD concept

5.1 Conceptual implications

In describing some of the existing technology we aimed at giving examples of applications that convey awareness and presence information. It is now appropriate to make a conceptual model for our proposal. Our task is to find ways to make innovative use of existing ideas and technology in order to provide awareness support for mobile users.

Drawing support from the observation that awareness and informal communication are two important factors of work, we propose a novel concept that integrates these two aspects by way of information technology. What we propose is the concept of an IPAD, or an *Interpersonal Awareness Device*, which constitutes a class of mobile IT devices with the overall function to support and enhance what we have titled group awareness of presence. Further, we conceptualize an IPAD to be a hand-held or wearable device enabling it to be used in *mobile settings*.

We intend for the IPADs to be used by members of a group, aiming to strengthen the members' awareness of each others presence. Our idea is to reduce the sense of physical distance between distributed people by creating a "virtual" link among them, and to let the IPAD convey this to its user. It is intended to be personal device - when in use it is associated with a specific member of a group and serves as an extension of the user's personal space. However, realistically we can see how one single device may serve several users and be an extension of a group's collective awareness.

5.1.1 Communicative

As the name is intended to imply, IPADs are used interpersonally to convey awareness between their users. The IPADs are mediums which provide *continuous awareness information.*

By some method (e.g. wireless communication) an IPAD will scan the physical co-location for other IPADs and gives indication (audible, visual, tactile, etc.) when the presence of another IPAD is detected. In order for IPADs to be detectable by each other, they must broadcast their presence by sending out signals of some kind (e.g. infrared or radio signals).

5.1.2 Comfortable

IPADs should be small and designed to be comfortably worn or carried at all times. Being continuous, an IPAD must reside comfortably in the background of

attention, letting the user be comfortably attuned to it even when it is active, i.e. be a form of calm technology.

5.1.3 Functional

IPADs are devices, and as such they should be designed to have a particular purpose and to achieve a particular effect. They should be self-contained devices, with function and form fully integrated. This means that they should be self-sufficient in the sense that their function is not reliant of external services, or devices other than other IPADs.

We intend for the IPAD to be a contact promoter rather than a mediator. This means that the IPAD is used as help for initiating and maintaining contact but not for communication and information exchange. IPADs are meant to extend the range of awareness provided by our ordinary senses, so that for instance two users may know that they are in physical vicinity of each other even though they are not close enough to directly see or hear each other.

5.2 How are IPADs different?

The Lovegety is the one example that comes closest to meeting the required properties of an IPAD. It is a small device, designed to be carried around, and provides continuous awareness information by audible and visual indications of another Lovegety's presence. By doing so, it functions as an initiator of communication between people. However, there are two big differences between how we envision an IPAD, and the Lovegety. First, and most significant of all is that the Lovegetys aim at bringing strangers together while the IPADs are meant to maintain awareness between people who already constitute a group. The second difference concerns the idea of calm technology. The Lovegety is very attention demanding, with a penetrating sound indicating the presence of others. It is not possible to let the Lovegety reside in the background of attention when it is has a sound that is discomfortable. However, these features of the Lovegetys that make up the most significant differences between them and IPADs serve the Lovegety well, but also account for the reasons to why Lovegetys are not IPADs.

Both the Portholes and the ICQ application provide their users with continuous awareness information. Both applications are capable to function as contact promoters and thereby initiate communication. However, both are immobile and dependent on the external services of databases and servers. Even though there are ICQ version for mobile devices, we do not consider them in the current discussion. For such a mobile version to be truly powerful, the user would have to place attention to it in the center, and that is not the strength of ICQ as an awareness distributor. What is inspiring with the Portholes and the ICQ applications is their capabilities to reside in the periphery of our attention.

The Active Badge system provides information about other users presence. Why is it different from how we envision the IPAD system? The most obvious weakness of the Active Badge system is that it does not provide continuous awareness information intended for the badge wearers. The function of the badge is instead to report its presence to a centralized system which does not provide all users with the same information. In this sense the Active Badge is more similar to a surveillance system than to an IPAD, and the Active Badge system has in fact been accused of being such a system. We believe the reason for that partly can be found in the Active Badge's unidirectional way of conveying presence. As the system is intended, the presence information is not conveyed to the individual users but rather to a central server for processing. A majority of the people who first learned about the system pointed out that due to privacy issues they were not sure they would want Active Badge installed in their work environment (Want et al., 1992). This fact is important and we consider it a weakness of the system.

6.0 The Hummingbird project: The making of an IPAD prototype

To explore the IPAD concept, we have constructed a proof-of-concept prototype, the *Hummingbird.* The Hummingbird is a small portable device designed to support awareness of presence between group members frequenting the same physical space. The Hummingbirds give members of the user group constant aural and visual indications when other group members carrying Hummingbirds are in the physical vicinity. The Hummingbird was given its name in the initial stage of the concept development phase, when the idea was for them to 'hum' when they got close to each other.

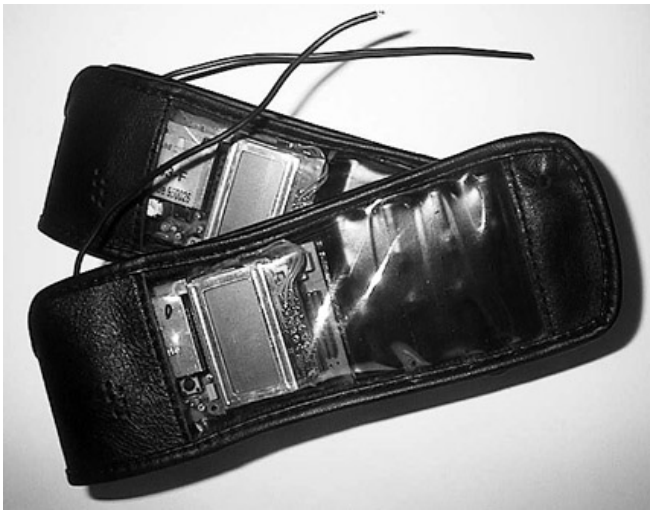

FIGURE 7. Two of the first Hummingbird prototypes. We kept them in carrying cases to protect the hardware during the user evaluations.

6.1 Prototype pondering

Being dissatisfied with the fact that most information technology is highly demanding when it comes to user attention and interaction, and that functionality is often tied the location of the user's desktop computers, we wanted to find a different approach. Inspired by the ideas of calm technology, we wanted the Hummingbird to be active in the background of the user's activities. One of the initial requirements of the prototype was to minimize the level of interaction necessary for it to be useful. The desired device is one that does not depend on user interaction for its function. Being very well aware that such a property is

more often not a feature of information technologies (Weiser & Brown, 1996), we knew that we were up for a challenge.

In addition to minimizing the level of user interaction, we wanted to minimize the level of attention that was demanded. Again, inspired by the ideas of calm technology, we wanted to let the Hummingbird be a device that utilizes non-intrusive methods to communicate information at the periphery of human perception. Ultimately, the Hummingbird should work as an extension of our normal senses, such as vision and hearing, and thereby extend the range of awareness in a physical environment.

A Hummingbird should also be comfortably portable, since it intended to be used continuously to provide awareness information. A small and well-designed device is therefore essential, otherwise it will not be practical to carry around.

6.2 Design implications

Even though the concept is simple -”devices that hum when they are close to each other”- it could be implemented in various ways. Below we describe some ideas that came up during the rapid prototyping phase, and that we eliminated outright.

6.2.1 Infrared light signaling

A positive feature of infrared light signaling is that it is inexpensive. It is used in various commercially available devices such as remote controls, infrared ports on some PDA’s and calculators, something that has contributed to its low price. Infrared signaling has a second positive feature in that its use is not regulated.

However, a solution involving infrared light signaling would require the Hummingbirds to be in direct view of each other or they would not be able to detect each other. Infrared signals are contained within the walls of a room and would therefore not be able to either detect or carry awareness information outside the room. Infrared signals can not penetrate solids, but must have a clear passage to a receiver in order to deliver the signal. Solving this problem by introducing a mediating device, as was done with the Active Badge (Harter et al., 1994; Hopper et al., 1993; Want et.al. 1992) would not provide an acceptable alternative since it would cripple the Hummingbird system, making it dependent on a mediating infrastructure rather than being the self-contained device we had in mind.

6.2.2 A desktop-based implementation

A desktop-based solution, such as ICQ or the Portholes, does obviously not provide an attractive alternative for a device that is intended to be mobile. We envision the IPAD to be a portable device not dependent on the location of the user.

Moreover, in line with our ambitions in the Mobile media and entertainment research program, we sought to develop an artifact that was usable in mobile situations.

6.2.3 High attention demands

Many applications and devices are very ”loud” and attention demanding. In the light of our experiences with devices such as the Lovegety we feel it important that the Hummingbird had presence indicators that were subtle and non-intrusive. Our ambition was to have the Hummingbird be as close to the calm technology ideal as possible. Penetrating sounds and intense visual indications can therefore not have a place in our implementation.

6.2.4 Built-in functions

It was essential to us to make the Hummingbird as simple as possible. A prototype that was given a built-in set of situation-dependent rules to govern its actions did not seem like a satisfactory solution. We have mentioned the Lovegety, a device that will beep only when two differently colored Lovegetys (on the same setting) are close. The Lovegetys are a commercial success, and the built-in rules by which they act serve them perfectly, but we did not want to limit our Hummingbirds by restricting their view of the world.

6.2.5 Information sharing

No Hummingbird user should have access to information that other users do not. When one user’s Hummingbird detects another, both Hummingbirds should convey each others presence. We feel this was important in reducing the risk of making the Hummingbirds a surveillance system.

6.3 Prototype: hardware and software

We soon concluded that short-range radio communication between the Hummingbirds would provide the best option. Radio signals are not directed as in the case of infrared light signals, and they are not contained within walls or stopped by other solid objects. When deciding on radio communication we also had to make sure that we picked a transmitter that sends on a non-regulated frequency. We also decided to use a computer, small enough to be portable, instead of dedicated circuitry, so that we could easily develop and modify a program to control the Hummingbird.

The very first Hummingbird was developed on the *Mini Board 2.0* (Martin, 1993), a single-board computer designed at Massachusetts Institute of Technology, originally for a LEGO Robot Design course held at MIT. The Mini Board is controlled by a Motorola 6811 8-bit microcontroller with 256 bytes of internal

RAM and 2K bytes of electrically erasable programmable ROM (EEPROM). Its small size, 5x8,5 cm, low power operation, and programmability made it an ideal computer candidate for the Hummingbird.

We added a radio transceiver to one of the analog input-ports on the Mini Board. The transceiver operate on the 433,92 MHz, a licence exempt band and is capable of half duplex data transmissions at speeds up to 40 kbit/s over distances of 30 meters “in-building” and 120 meters open ground (Radiometrix, 981018). The initial Hummingbird specification did not propose a display, but early on in the software development process we decided to add one to help us work with and debug the Hummingbird software. We then decided to keep it, mainly because of the added information it provided. The 8x2 character display and a speaker were added to output ports on the microcontroller.

Using the Mini Board allowed us to experiment with both hardware and software and rapidly develop our ideas of a Hummingbird. However, the Mini Board hosts circuitry that we did not make use of, and was therefore bulkier than necessary. We therefore decided to construct our own circuitboard, tailor-made for the Hummingbird. The result was a much smaller device. Figure 8 depicts the Hummingbird hardware:

FIGURE 8. The second generation hardware: This tailor-made circuitboard is more compact and has been optimized to host a Hummingbird

The software running on the Hummingbird is written in assembler language. The program evolved through various implementations and modifications and the final result is basically an algorithm that alters between sending and listening for signals. Since the radio transceiver in use is a half-duplex module, it can

only either send or receive at one time, never both at the same time. To prevent two Hummingbirds' sending and receiving phases to coincide, a random function was added to the algorithm. When one Hummingbird detects the radio signals of another Hummingbird, a power signal is sent to the speaker and a subtle, chirping, sound is produced. The identity of the detected Hummingbird is shown on the display. The most recently detected Hummingbird contact is indicated by an arrow.

After reviewing the early designs, we had ideas of providing distance and direction indications. However, it is difficult to determine what direction radio signals come from, and to shield the antennas was such a big design challenge that we decided to discard that solution. Although not very successfully, we did experiment on how to measure signal strength so determine the distance to other Hummingbird users.

6.4 Using the Hummingbird

Four Hummingbirds were built and put into use. The Hummingbirds are intended to be personal devices, meaning that each user would have a specific Hummingbird each. To make the Hummingbirds specific, we were given an identity. The limited size of the display caused us to simply assign them the letters **a**, **b**, **c** and **d**. This makes it easy to associate the persons using the Hummingbirds with the corresponding letters. To make the prototypes easy to use, we encased them in off-the-shelf clip-on carrying cases as seen in figure 7 above.

Whenever two Hummingbirds are within range of each other, they produce a sound to indicate detection. The sound of the current prototypes is more of a chirp than a hum. Since the Hummingbirds provide continuous awareness information, they will chirp continuously as long as they can detect another Hummingbird's signal. In addition to this, each Hummingbird will continuously signal their presence. This has the effect of making it possible to determine how "crowded" the environment is of other Hummingbirds, simply by listening to the amount of chirping being produced. A single detected Hummingbird causes distinctively less chirps to be produced that if several Hummingbirds are detected simultaneously.

The Hummingbirds also display the identifying letters of the contacts, enabling their users to determine which of the other users are nearby. Only those contacts from which a Hummingbird receives signals will be displayed and they have the capability to display multiple contacts concurrently. If the other Hummingbirds in the group are absent, their corresponding letter will not be shown. Figure 9 below depicts the display. The letters are printed on the upper part of the display. The display in the picture also shows a hexadecimal number, which is the

result of our attempt to measure the strength of the detected signal. As of now, this number has no informative value.

The fact that the Hummingbirds produce a sound upon the detection of other Hummingbirds, effectively contributes to reduce the attention demands on the users. Even when they put their Hummingbirds aside the users would still know when another was detected, without having to constantly look at the display. A quick glance at the display would be enough to determine who else was nearby. By providing both visual and aural indications we provided ways to use the Hummingbirds in a more flexible way than if we had decided on using only one of the two.

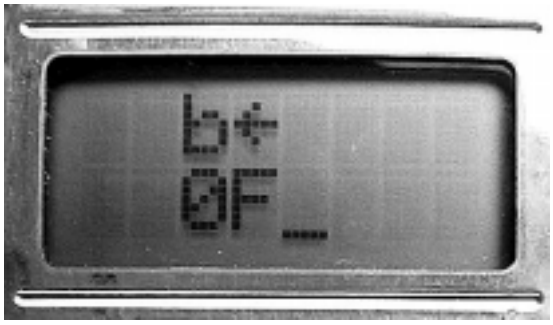

FIGURE 9. The Hummingbird display shows the identity of the contact, in this case represented by the letter ‘b’. The arrow points to the letter of the Hummingbird that was most recently detected. The hexadecimal numbers below show the attempt to measure signal strength and thereby get an indication of distance, but as of now provide no informative value

7.0 Evaluations

The objective of the evaluations of the Hummingbirds was to study how they affect groups by incorporating them into everyday situations. The test groups were formed to be balanced combinations of people who are familiar with the Hummingbird, and people with no prior experience of the prototype. We conducted three field-evaluations in which all test-subjects were equipped with one Hummingbird each. At the time of our evaluations, we had built four prototypes, limiting the size of the test group to four persons.

7.1 Evaluation frameworks

We performed the evaluations in two types of settings which we named *familiar* and *unfamiliar*. We define familiar settings to be environments in which people spend a significant amount of time, together with familiar people with whom they keep in casual contact throughout the day. Obvious examples are the home - together with family and friends, and the office or school - together with colleagues and classmates. In familiar settings, people may be associated with a physical location, such as their office, a lecture room or a specific building. We define unfamiliar settings to be places where people rarely or never are, or places where people are surrounded primarily by strangers. This may be while traveling abroad, while visiting another workplace, or at large gathering of people such as at a conference. In these settings, people are not associated with a location to the same extent. There are no natural, or obvious, reference points to where a person is likely to be located.

The Hummingbirds were evaluated in two settings we classify as unfamiliar: At the Roskilde rock festival and at a major scientific conference. We have also performed an evaluation in one familiar setting: The office.

7.2 Roskilde evaluation - an unfamiliar setting

The Roskilde field evaluation was conducted at the annual music festival in Roskilde, Denmark 1998. Every year, the festival attracts around 90 000 people from all over the world. The event lasts for 4 days and offers a great deal of variety in music and other attractions. The whole festival area is divided in a performance area and a camping area, covering a huge amount of ground. This was the test site for our first evaluation of the Hummingbird prototype.

We characterize the Roskilde festival as an unfamiliar setting since it is a large gathering of people, taking place only once a year, and in our case in a foreign country. Since the festival is so large and offers a great deal of variety in music and events it is very likely that people in a group get separated, either by choice or by accident. The festival offered a social event, where the relationships

between the participants were primarily social and informal. The group members would in general have strong wishes to hold together the group, even though they would split up temporarily every now and then.

As this was the first evaluation, one of the main objectives was to test the range and rate of contact of the Hummingbirds in a “real world” environment and to learn more about the ways in which this technology affects a group. The evaluation was carried out by people who were familiar with the IPAD concept, one person from the development team and three persons from the institute where the prototypes were built.

In order to carry out the test we considered it necessary to introduce limitations in both time and space. The time limit was due to battery performance and the fact that once the batteries were discharged, there were no possibilities to recharge them on-site. In addition, due to the delicacy of the electronics, we considered it too daring to carry the Hummingbirds with us at all times. Further, we realized that it was necessary to limit the evaluation to a test area to maintain control over the test and to increase the chances of establishing contact.

The test area spanned about 1500 meters in diameter and was crowded with people. The test itself was carried out during four hours. The task was to wander around and take notes on time, place and with whom contact was established. The participants were free to use the information provided by the Hummingbirds in any way they wanted to, making this an essentially open-ended evaluation.

7.2.1 Findings

The most interesting finding, as pointed out by the participants, was the evident sensation of togetherness when their Hummingbirds established contact. They came to expect, and even attempt to establish, visual contact with each other. Even when there was no incentive to get together with the other person, the Hummingbird link had a comforting effect. When the Hummingbird contact was interrupted, and the other person disappeared out of range, the sensation of disconnection was also evident.

The Hummingbird does not tell the users in what direction or at what distance people are, but in combination with the spatial information and personal senses such as vision and hearing, the Hummingbird may be helpful in determining the location of another person. The participants pointed out that when they were separated, they were actively looking for each other, and they used their Hummingbirds to find out when others were in the vicinity, i.e. to find out when it was meaningful to look for others at all. In addition, knowing that someone is nearby is in itself a comforting piece of information as pointed out by the participants.

7.3 The conference evaluation - an unfamiliar setting

The annual ACM SIGGRAPH conference on computer graphics and interactive techniques is a combined scientific conference and technical exhibition. It lasts for 6 days and attracts 30,000-50,000 people from all over the world. Like the Roskilde festival it is a large gathering of people, a sprawling environment with a multitude of activities happening simultaneously, and we characterize this setting as unfamiliar for the same reasons Roskilde was characterized as such.

Still intrigued by the Roskilde results, we wanted to further test the Hummingbirds in an unfamiliar setting. Assuming that members of a group in an unfamiliar setting have primarily social motivations for maintaining the group, we wanted to verify the Hummingbirds usefulness in maintaining group awareness.

Three Hummingbirds were brought to SIGGRAPH ‘98 in Orlando, Florida. One was assigned to a member of the Hummingbird development team, one to a researcher from the same institute but not part of the team, and the third to a person with no previous experience of the Hummingbirds. The participants stayed at 3 separate hotels, but met regularly during the conference and in the evenings. The participants’ different agendas caused them to spend most of the time apart. With the intention to use the Hummingbirds at all times, the participants used them extensively the first few days of the conference, until the prototypes started to fail in the Florida heat and humidity.

7.3.1 Findings

The results from SIGGRAPH were similar to those from Roskilde. The participants used the Hummingbirds extensively in situations when they were separated from each other and soon started to rely on the information that was given to them. For example, at the conference reception, the participants all arrived at different times and they all used their Hummingbird to determine who of the others were and were not there. The first person to arrive would not look for the others until the familiar ‘humming’ sound notified that someone had arrived. On the other hand, knowing that you are not the first person to arrive was described to have a comforting effect. For this event, the participants had not agreed on a specific time and place to meet, so the Hummingbirds were particularly useful. At some events, such as an agreement to visit a particular presentation, the Hummingbirds were not necessarily used as the important issue was not to get together as a group, but to simply know the others were attending.

7.4 Viktoria evaluation - a familiar setting

The Viktoria evaluation was conducted at the Viktoria Institute in Gothenburg. The participants spend a great deal of time there, surrounded by familiar people and engaged in routines and everyday activities. Their offices are located across three floors in the building, a condition that substantially decreases their aware-

ness of each other and makes it difficult to know when other group members are present or not. The awareness support they do have, such as ICQ, telephones, or e-mail, are bound to their desktops, and as people begin to spend less time at their desks, this support can not always be utilized.

In this evaluation we wanted to test our system in the in comparison formal and familiar setting the Viktoria evaluation offered. We have described the importance of informal communication in organizations, and have adopted the definition of informal communication as something taking place in a face-to-face setting. This implies physical proximity. Knowing when someone is in the physical proximity therefore has a promoting effect on informal communication. The main objective of the evaluation was to study how the Hummingbird can act as a promoter of awareness at a workplace. Would it affect the group differently from in the previous evaluations?

Four test participants carried Hummingbirds for a full working day, using them as they saw fit. The only requirement and limitation was to keep the Hummingbirds powered-on at all times. We distributed the Hummingbirds the day before the test took place and did not collect them before the day after when the test was ended. This was to make sure that the entire day was included in the test.

7.4.1 Findings

The effects of the Hummingbirds in the Viktoria evaluation were far less pronounced compared to the results from the unfamiliar settings. The most significant finding was that the participants did not use the Hummingbirds as actively, but rather let them remain in the background of attention. Sitting in their offices, working and concentrating on other things, the participants were not very watchful of their Hummingbird. Only when there were distinct changes such as during hours of the day when people move in and out of the building more frequently would the Hummingbird be moved into the foreground of attention. This partly suggest that the need to actively use, or to be constantly aware of other people's presence is not as important or as interesting as in the other settings where the Hummingbirds were evaluated. A positive finding was that the humming sound was non-obtrusive enough to not demand foreground attention.

7.5 Overall evaluation results

As a first note, it is significant that the test users found the Hummingbirds fun to use! All participants talked positively in general about the experience, indicating that the Hummingbird has entertaining as well as practical advantages.

However, the users sometimes experienced frustration due to the fact that the Hummingbird does not aid them in determining an other user's position. The wish to be able to determine the location of others was stronger in the unfamiliar settings, or in situations where group members did not have a physical location

associated with them. Although this is not an intended function of the device, this finding is obviously important to address. As the Hummingbird was designed to be an awareness indicator rather than a locating device, this functionality was deliberately not implemented. Instead, the Hummingbird is intended to be used to indicate when it is meaningful to use communication and locating devices, such as a mobile phone.

We collected revealing information from the evaluations about how the Hummingbirds affect groups. Our results clearly show that they effectively contribute to group members' awareness of each other, but also that they had different effects in the two different settings they were evaluated in. At the Roskilde festival and at the SIGGRAPH conference, the participants reported a much more active use of the Hummingbirds while at the office the Hummingbirds were placed in the background of attention to a larger extent. Both at the festival and at the conference, the participants were paying a great deal of attention to the Hummingbirds, actively using the information provided in a conscious manner, to aid in locating the others. At the office, on the other hand, the devices were often just placed on the desk or clipped onto the wearer's belt. The Hummingbirds were simply placed in the background, and the users would only sporadically pay attention to it; for example when a pronounced change in the hum occurred, or when the need to locate another group member arose. This particular finding has led us to believe that a continuous update of presence information may not be crucial in these types of situations.

An explanation for the difference in use, we argue that in a familiar setting, such as a workplace, people are associated with a physical location, i.e. their offices, a lecture room, or the building they are located in. In unfamiliar settings, there are weaker or non-existent associations between person and location. This points to a key issue, that the Hummingbirds are used differently, depending on how strongly each individual is bound to a physical location. When there are no person-location associations, the Hummingbirds are used more actively than when there exist such associations. This is not solely determined by what type of setting the group is found to be in. At the festival, groups members had a physical reference point, namely their tents, and the Hummingbirds were used more actively when this reference point was not the most likely place for people to be at. At the conference, group members had various physical reference points, for instance at certain presentations they were all planning to attend, and the Hummingbirds were used less actively in those situations than when people had no idea where the others were. In conclusion, we believe that when a person is associated with a location, the Hummingbird is more actively placed in the foreground of attention, as it provides a sense of group awareness in a mobile situation.

8.0 Concluding discussion

The overall experience working with this thesis has been a positive one. We have described the concept of inter-personal awareness devices and provided a functioning prototype to investigate and illustrate our ideas of such devices. Our evaluations pointed out positive as well as negative aspects of the Hummingbird prototype, enabling us to stepwise refine our conceptual ideas of inter-personal awareness devices.

Before our evaluations of the Hummingbird prototypes we were mainly envisioning them to be most useful in familiar settings, like an office or some other workplace, like so many other awareness applications are used. However, our evaluations showed that the Hummingbirds were far more effective when used in unfamiliar settings, such as at the Roskilde festival and the SIGGRAPH conference. Although our first ambition, to introduce mobile awareness devices into an office environment, was successful since very few awareness applications used in these surroundings are mobile, we have come to believe that the Hummingbird's true domain is in the unfamiliar places.

Our scope has been to experiment with group members' awareness of each other's presence in a physical space. Awareness is a term that encompasses many different variables, such as a feel for the direction and distance to others, what they are doing, who else is there, and so on. Without these indicators, the awareness of others as we experience it is very different and unconventional in comparison to when those indications are present. With the Hummingbirds, we wanted to elaborate on the idea of pulling awareness support out of the desktop computer and making it more mobile. The scaled-down interface proved to be frustrating to some extent and most people who have had hands-on experience with the Hummingbird expressed a wish to know at least in what direction others were.

Some users have expressed concern that a device like the Hummingbird may provide information that could be abused. This is a concern that is important to address. Our ambition has not been to build a product for a market. Constructing the Hummingbird intended to test our idea of Interpersonal Awareness Devices and to study the feasibility of such devices. The tests were performed by users and peers who got hands on experience with our prototype. It is important to point out that information technology put in the hands of people can never be neutral. It is possible that a user may use the presence information the Hummingbird provides with malicious intent. Many CSCW applications, and especially those who are concerned with transmitting presence and absence information are constructed so that they may be used as surveillance systems (see for example Active Badge, @Work, Portholes). Is this a curse? Or is it in the nature of CSCW applications? These questions do not have an immediate answer.

As our intention has not been to work with and solve this particular problem, this aspect is beyond the scope of this thesis. However, we are aware of the challenges these issues present if a device such as the Hummingbird was to be deployed into a market.

In the work with this thesis, we have faced the problem - *How can we, through information technology, provide awareness support for mobile users?* To answer this question we have studied a few existing awareness applications from which we have drawn design implications for a novel approach to mobile awareness support. We have proposed the IPAD concept, which accommodates a class of information technology devices with the aim to strengthen interpersonal awareness. Developing one such device; the Hummingbird, demonstrated that it is both simple and possible to provide mobile users with information technology support that increases their awareness of each other.

9.0 Ideas for the future

Our study has convincingly showed us that mobile devices that support group and group awareness are both interesting and useful. We believe that the IPAD concept and the Hummingbird are suitable for further development. Ideas for alternative technical solutions have already resulted in the construction of a second generation Hummingbirds, built on Nintendo Game Boy hardware. This platform offers a much improved user interface, with a larger graphics display and control buttons gives a new dimension to the IPADs than was previously intended. The buttons enable the user to provide input and ideas around implementing a simple message passing system have taken form.

The groups that the IPADs are meant to support may also be extended to contain items and activities. Although the coffee-maker generally is not a mobile item, it may be interesting to connect an IPAD to it that sends out a signal as long as there is coffee in the pot. It may also be interesting to connect IPADs to motion detectors. When people pass the detector a signal can be transmitted. Other IPADs could be connected to stationary computers and in that way be connected to an Intranet or the Internet, transmitting various information to the mobile devices, such as when their owners receive new e-mail. These are two examples of ideas on how to extend the functionality of an IPAD to involve awareness of activities and items within a group.

For devices that people are supposed to wear or carry with them at all times, form and design are important attributes and should be carefully considered in relation to their functionality. Some ideas for a future Hummingbird have already been presented by industrial designer Jona Bjur. He envisions them as small handheld gadgets, pleasing to the touch and eye. We have also worked together with jewelry designer Gunilla Grahn to find forms for a future IPAD.

FIGURE 10. Will a future Hummingbird look something like this? Models by industrial designer Jona Bjur.

This thesis has suggested something that should be further explored. We have described how the Hummingbirds were used in different ways in the different settings they were evaluated in. Further user evaluations with larger test groups should be conducted in order to fully understand the reasons for this difference.

A second issue to be explored further is based on the fact that people more often belong to several groups rather than just one. Some people might claim that people are not members of groups at all, but rather networks. A future inter-personal awareness device must therefore explore the possibility to support multiple group memberships and ‘networking’ capabilities.

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