Gothenburg Studies in Informatics Report 27, May 2003, ISSN 1400-741X

Local Mobility

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Doctoral Dissertation

Abstract

This thesis is a collection of six papers that explores new IT use in local mobility, i.e., the mobility of people in limited areas such as office environments. The overall research question asked in the thesis is: *how can work related locally mobile interaction be supported using context aware applications*? To answer the question, I have participated in theoretical and empirical investigations, as well as elaborated on design ideas that have been implemented and evaluated empirically.

The empirical investigations revealed two main results: The concepts of "scalability through cultivation" and "mobile meetings." Based on the concept of cultivation and coordination theory, as well as a field study of locally mobile work processes in a plant, we introduce the idea of "scalability through cultivation" as a novel perspective on how to scale up (mobile) work processes. Our claim is: to scale up the mobile work processes investigated, the co-ordination between operations should be improved to decrease the risk of disruptions. The second empirically based result is the concept of "the mobile meeting," which is a work-related type of informal communication between locally mobile people in office environments, which according to our fieldwork, plays an important role in office work.

Based on the fieldwork, design elaborations and theoretical studies, we have developed and evaluated two novel application concepts for local mobility: The "Proxy Lady" and the "Desk Panel." Proxy Lady is a novel context aware application that uses the proximity of people as a means to support opportunistic interaction. According to our evaluation results, people recognize the task domain and find it important. The Desk Panel application also utilizes proximity as a means to offer novel application support. Desk Panel is a combination of a stationary and mobile system, which lets locally mobile people with handheld devices easily access personal information such as emails, on large screens placed in the office environment.

Acknowledgements

First would like to thank Fredrik Ljungberg and Bo Dahlbom who have been my supervisors since I started the work on my master thesis a few years ago. I have been very lucky to work with those two rather different persons who complement each other in a very good way.

I would like to give special thanks to friend, colleague and co-author Jens Bergqvist, who helped me a lot in the process of writing this thesis (as well as helping me when things felt impossible). I would like to thank my co-authors, Lars-Erik Holmquist, Steinar Kristoffersen, Peter Ljungstrand, Johan Redström and Johan Sanneblad. I would also like to thank my colleagues at the department of Informatics, the Viktoria Institute, the Internet Project, Newmad Technologies AB and all other persons that I have been working with in my research.

This thesis would not have been possible to write without funding received from the Swedish Research Institute for Information Technology through the Mobile Informatics programme at the Viktoria Institute.

Finally, without my wife, Ulrica, my family, my friends and their support I would not have been able to complete the work. I would like to take the opportunity to thank you for all the love, support and patience you showed me the past, hectic years.

Per Dahlberg

Göteborg, May 2003

Contents

Section one

Context Aware Applications Supporting Local Mobility

1. Introduction

The development and adoption of communication technologies seem to have increased the communication between people all over the world. However, the consequence is not decreased travelling. For example, the number of passengers flying from Swedish airports increased from 3.7 million in 1972 to more than 16 million in 2002[1]. In other words, remote communication and travelling have increased simultaneously.

You may think it is strange that people *both* travel and communicate more. If you can communicate with remote people without having to go there, then why has travelling increased? One reason why seems to be that the physical meeting simply still is superior to technology mediated communication. Just as the introduction of computers in the office increased the number of documents produced (the vision of the paperless office did not

[1] When comparing the figures of 1999 and 2002, there has been a 3 percent decrease of the number of passengers flying from the Swedish airports. I leave it unsaid if that is due to Al Qaeda attacks, war threats or worse economic situation in Sweden. In any case the increase compared to the 1972 figures is indubitable.

come true, at least not so far), the introduction of communication technologies seems to increase travelling. Inasmuch as the paper document is superior to an electronic document on the screen, the physical meeting seems to be superior to the virtual meeting.

The point is not that physical communication is better than remote communication *in all situations*. Email, phone, fax, chat, etc., are important means of communication for many purposes. However, those means cannot reproduce all the properties of the physical meeting and is therefore not as "rich" as face-to-face communication. On the other hand, imagine what it would be like to replace all email exchange or telephone calls with travelling.

There is no generally accepted definition of mobility in the literature. On the contrary, the conceptualisations and definitions found concern rather different issues, ranging from the relation between different mobile situations (e.g., Kristoffersen and Ljungberg 1998, Kakihara and Sørensen 2002), to specific types of mobility (e.g., *Paper 2* of this thesis, Belotti and Bly 1996, Luff and Heath 1998).

One type of mobility is travelling, e.g., a person going from one city to another. Another type is wandering, i.e., people walking around in an office, e.g., the systems administrator who walks around in the office landscape to assist users. The latter is also an example of *local mobility* (see Belotti and Bly 1996), which is the main focus of this thesis.

Local mobility takes place in a spatially "local setting," e.g., an office landscape, where the mobile person interacts with other people and artefacts. The local setting may be a place where the person usually works or lives (which I call the "home base"), but also a temporary base, e.g., a hotel lobby or a customer's office.

One reason why people are mobile is that they need to *interact* with other people (Luff and Heath 1998, Kristoffersen and Rodden 1996) or artefacts (Belotti and Bly 1996). This is also true for local mobility as we found in our studies (*Paper 2*). In our case, people typically became mobile to visit someone

else's office or attend a meeting. However, people were also mobile to make use of artefacts, e.g., the Xerox machine or the printer. Other examples of mobility caused by an artefact are: a businessman visiting a lounge at an airport in order to check her emails on a terminal with Internet connection, or a systems administrator walking to her PC to reboot a computer in the network.

Despite the rapid development of computer technology and the importance of mobility in society, there is not much current IT support for local mobility. The most common tools for locally mobile people are probably the mobile phone and the handheld computer. However, even though these tools may be useful for locally mobile personnel, there are few applications that are explicitly designed for such activities. So, what types of applications may be useful in local mobility?

My focus in approaching this question is not on local mobility in general, but on *the interaction* that the locally mobile person is engaged in with other people and artefacts. In exploring application concepts for such support, I focus on *context awareness*, which has been used increasingly the last couple of years to support local interaction (see, for example, Schilit *et al.* 1994). The main characteristic of a context aware system is that it automatically adapts its behaviour based on data about its surrounding. One example is a navigation system, which based on positioning data automatically suggests the best way reach a particular destination. Based on the discussion above, I define the research task of the thesis as follows: *How can work related locally mobile interaction be supported using context aware applications?*

To accomplish the research task described above, I have participated in empirical studies with the objective to gain knowledge of how people are locally mobile and what they do in these situations. In the thesis I report the findings of these studies, the systems that were designed based on these findings, and the evaluations of these systems.

The thesis includes six research papers and an introduction. The papers report from different stages of the

research. The structure of the introduction is as follows. In section 2, local mobility is discussed. Section 3 contains a description of the research approach, regarding both the general approach, as well as the method used in the research. In section 4 and 5 the results are summarized and, finally, discussed in section 6.

2. Local mobility

Local mobility takes place in a *local setting*, where mobile people *interact* with other *people* and *artefacts*. I seek to support work related local mobility, using systems that are *context aware*, running on platforms that are *mobile* and *networked*. The purpose of this section is to define and discuss these key terms of the thesis in more detail.

In the first part of this section I will discuss the main issues of the local mobility domain and how mobility relates to mobile IT use. In the latter part of this section I will go through the application platforms relevant for this area.

2.1 The local mobility domain

Mobility is a term that is difficult to define explicitly. Everything that can move is in a sense mobile. Depending on what point of view we take most things can move around. Under what circumstances can we say that something or someone is mobile? Let us start with considering how “mobility” has been used in informatics research.

2.1.1 Mobility

Mobile computers have often been discussed in contrast to stationary computers. Stationary computers are wired, networked computers that are (more or less) tied to a location. Even though a PC or workstation is possible to move (after all, someone brought it to your desk), you cannot really use it while on the move. Mobile computers, on the other hand, are developed specifically for people on the move, which is not to say the support they give the mobile user is suitable. For example, the mobile computers of today are in many ways difficult to interact with while walking around or while driving a car. Still, from the point of view of mobility they are of course usually much better than stationary computers, even though there are some exceptions where stationary computers are useful when being mobile.

Historically, most computing technology has been developed for stationary settings, including networking technologies such as the TCP/IP protocols as well as most operating systems. In informatics the main research task has been on the use of stationary computing technology for stationary use domains.

Recently, however, mobility has gained increased recognition. For example, the number of research contributions on the topic has increased significantly. As opposed to the focus on the mobile technology, the focus in my research is on the mobile *use* of IT. The research contributions on the topic concern case studies of mobile IT use (Ljungberg 1997, Whittaker *et al.* 1994, Bowers *et al.* 1995 and Rouncefield *et al.* 1994), novel applications (Myers *et al.* 1998, Fano 1998) and user interfaces that match a mobile use context (Want *el al.* 1995, Want and Hopper 1992, Schilit 1995).

Let us now consider the concept of mobile work as such. What is mobile work, or work related mobility? For example, is a person attending a meeting in the office mobile? Is a person working from home mobile? Is a travelling sales person mobile? The sales person's workplace is after all the car, where she

spends most of the working hours. In the car she is sitting still. On the other hand, the car takes the sales person to different customers. At the customer's office the sales person is likely to sit down to discuss her products and services with the potential customer. You would probably say that the work of the sales person is much more mobile than that of an office worker sitting at her desk.

However, according to out fieldwork (e.g., *Paper 2*), office workers do not just sit at their desks but may very well spend much of their working day wandering around in the office. On the other hand, when the sales person is sitting down at the customer's site, she might be able to connect her laptop to the Internet and use it just as she would in the office. When wandering around in an office landscape it is difficult to use a laptop. Office staff working with IT support may wander around the office landscape as a defined work task (e.g., Ljungberg 1997). Compared to a developer who mainly sits at the desk, the IT support staff could be considered mobile. However, the travelling salesman would probably be considered to have a more mobile work situation, even though she spends much time sitting in her car or at the customers' sites.

As these examples show, it is not easy to define mobility explicitly without considering the context. The exact boundary between being mobile or not might not be fruitful to draw using only spatial terms (Kakihara and Sørensen 2002). Kakihara and Sørensen point out that it is important not only to describe mobility in spatial terms, but also consider the interaction performed, including context and temporality. In their terms, there are three dimensions of mobility: the spatial, the temporal and the contextual dimension.

Below is a conceptualisation (Kristoffersen and Ljungberg 1998) of mobility that can serve as a starting point for the discussion.

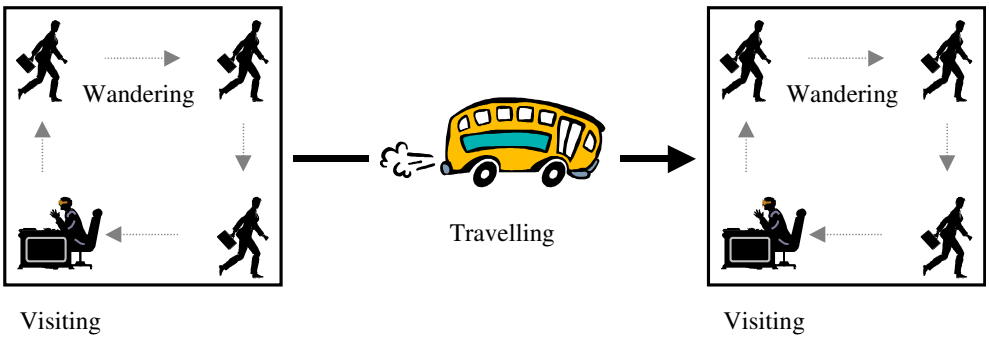


Figure 1. Ljungberg and Kristoffersen's model of mobility

The model above is an attempt to define typical modalities of mobile IT use. This taxonomy was designed to describe mobile work rather than mobile life in general. Therefore, the terms tend to focus on professional situations.

The first modality is called "wandering." Wandering is when a person is moving around in an office. "Travelling" is when a person is going from one place to another, in a car, bus, airplane, etc. The third modality is "visiting." This modality concerns a situation when a person visits another location than the normal "home base." As a consequence, the visiting person probably does not have access to all normal resources (e.g., files, binders and documents). A visiting person can in some cases be wandering, for instance when trying to find a person at a customer's office.

Others have used the term of "local mobility" instead of wandering (Luff and Heath 1998, Bellotti and Bly 1996). Local mobility describes a less specific situation, where the locally mobile person might be wandering at times. Local mobility can be used to describe mobility at a person's "home base." At the "home base" people have collected the resources they use to do their work, e.g., the PC, documents, binders, etc. (Kristoffersen and Ljungberg 1998). This is also typically the place where to find the co-workers.

Local mobility can take place at the user's home base, but it might not always be the case. Sometimes, locally mobile situations do not have anything to do with the home base. It is,

of course possible to be locally mobile, even if you are just visiting a customer. The “home base” is not a requirement in the definition of local mobility.

It is not obvious that all people have a home base. By that I do not mean poor people without a place to stay, but rather people who travel so much in their work that they simply do not have a specific home base. There are people who travel between cities, countries or even all over the world on a regular basis. At the places such “modern nomads” visit, they can very well be locally mobile. However, the place in question is not the home base, simply because they do not have one. You could argue that all the places the nomad visits are the home base, but by doing so you cannot define home base in terms of the resources the person has available to do the work. If all resources become electronic and mobile, which they are not today, then this problem would be solved. But then a person is always at her home base, and the term has lost its meaning.

Yet, it is sometimes useful to make a distinction between local mobility at the home base, and local mobility in general. The reason why is the additional resources that may be available at the home base. For example, books or manuals might be available only at the home base. You may also be more likely to meet co-workers at the home base, inasmuch as they are not mobile in their work.

When someone wanders around, how large can the area be to still be called “local?” Does local mean “within the company,” at the specific floor of a house, etc.? It is cumbersome to try to exactly define “local” without considering the context. For example, in a company with a global sales force, the sales force of the region of the headquarters would probably be defined as “local” even though it is better characterized as regional “travelling” and “visiting” (Kristoffersen and Ljungberg 1998). The case studies I report from in the thesis are all examples of local mobility. The cases investigate mobility in rather limited physical areas. To walk from one corner of the office (in *Paper 2*) or workshop floor (*Paper 1*), to the other corner took less than a minute.

In the literature we find some empirical studies of local mobility. Bellotti and Bly (1996) report from a study of a dispersed design team of two groups, one at each location. The teams were not so much aware of each other's activities. Both teams were often locally mobile (i.e., mobile within the limited office space), either to communicate with colleagues or to use shared resources. Bellotti and Bly's (1996) study is an example of how people become locally mobile to interact with people or artefacts. The focus of Bellotti and Bly is mainly on how to obtain a general awareness of the ongoing activities within distributed groups, not so much on supporting interaction among the locally mobile people in each group.

Luff and Heath (1998) present three types of mobility, based on empirical studies analysed from a "mobility in collaboration" perspective, i.e., how people collaborate and communicate when being mobile. The first type of mobility they describe is local mobility. Luff and Heath use the term "local mobility" similar to Bellotti and Bly (1996). They do, however, emphasise the face-to-face interaction between locally mobile persons, while Bellotti and Bly focus on how local mobility implies new challenges for designing IT support for awareness between distributed groups, which Luff and Heath describe as remote mobility. Luff and Heath also introduce the term micro mobility that describes "…the way in which an artefact can be mobilised and manipulated for various purposes around a relatively circumscribed, or 'at hand', domain…" (Luff and Heath 1998, p. 306). "Micro mobility" is, hence, a kind of property of a piece of technology, rather than a type of mobility of persons. Even though you may think it is strange to include mobility of technology in a discussion of person mobility, the concept of "micro mobility" can been useful.

Many studies of local mobility focus on *the interaction* between the mobile person and other people (e.g., Whittaker *et al.* 1994). However, the "local interaction" does not have to be restricted to "person to person." The interaction can also be between a person and an artefact, e.g., entering information on the whiteboard, adjusting the volume on the stereo, or

examining shared resources within a project (Belotti and Bly 1996). I use "local interaction" to describe a locally mobile person's interaction with people and artefacts.

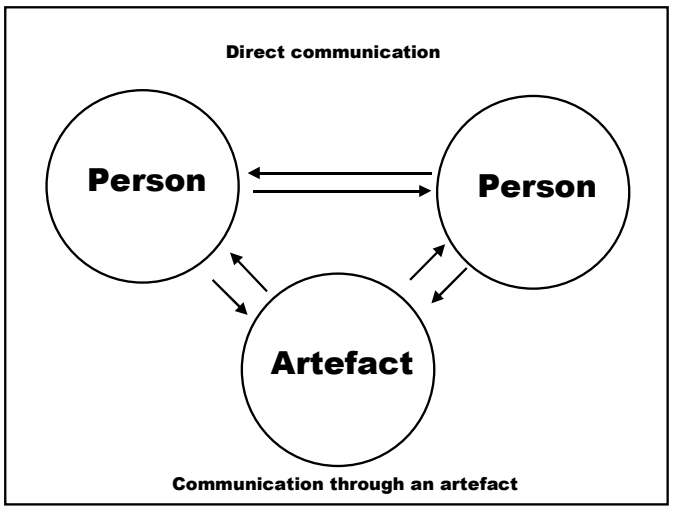


Figure 2: The Dix and Beale framework for CSCW.

Dix and Beale (1996) introduced a framework for CSCW, in which they describe direct communication between people and communication (between people) through artefacts (see figure 2 above). Direct communication is, according to Dix and Beale, when people are engaged in oral conversations. Communication through artefacts is when the communication is mediated through an artefact. Examples of this type of indirect communication includes when sorting paper in different trays and attaching messages on a message board. This might sound similar to "interaction with artefacts." However, interaction with artefacts does not always involve communication with other people. For instance, when buying a sandwich at a vending machine you interact with the machine (artefact), but you do not probably communicate with other people through that artefact. "Communication through artefacts" is therefore a specialized case of "interaction with artefacts."

To summarize, local mobility takes place in a *local setting* and can take place near or far from a user's *home base*. A

person's home base is the place where the main resources (e.g., IT support, binders etc.) are located. Locally mobile persons are typically *wandering* and are commonly engaged in *local interaction*, either with *other people* or with *artefacts*.

2.1.2 IT use in local mobility

One important way to support local mobility with is "context awareness." The term was coined by researchers at Xerox PARC (Shilit 1995), who defined it as follows:

> "Context aware computing is the ability of a mobile user's applications to discover and react to changes in the context in which they are situated." (Shilit 1995 p. 20)

Context awareness denotes an application's ability to automatically collect data from its environment (or context). Context aware systems have gained increased attention, both within academia and industry, as mobile technology has emerged the last couple of years. There are many different types of context that can be used in mobile systems. Many systems use the physical properties in the context, such as location, tilt and temperature, but other types of context include infrastructure and system context (see Dix *et al.* 2000).

In commercial systems the most prominent context to use is the location of the user. For instance, navigational systems for cars and boats have been widely adopted the last couple of years. Another example is Shopper's Eye (Fano 1998), which uses the location of a user within a shopping mall to present offers from shops in the mall. The Cyber Guide (Abowd *et al.* 1997) is an application for handheld computers, which was designed to guide a user through the open house sessions at a university. When a user was close to a specific item, room or house, information about that object was shown on the display automatically.

Most location based systems use position to retrieve the *absolute position* of the user. The absolute position is a co-

ordinate in the world. A co-ordinate can be used retrieve information of the *location*, such as an address or even more detailed information, such as specifying an office in a building. Active Badge (Want and Hopper 1992) is an example of a system that extracted location, rather than position. The system consists of a badge that a user wears as a nametag. The badge has an infrared (IR) transmitter that periodically sends the ID of the user. In each room where the system is used an IR beacon is mounted. When a user enters the room, the beacon can retrieve the ID of the user and submit the information to a central database. The information in the database is used to extract information about where people are located, what people are located in a room, and so on. When submitting information on the location of a person to external systems, there is a discussion about privacy (e.g., Harper 1995), to which I relate in the individual papers of this thesis.

Another type of positioning is *relative position*. A relative position of an object is described in relation to other (sometimes moving) objects. For instance, "Is Simon here?" is an example of a question concerning a relative position. Simon has an absolute position, and so do I. The relative position is how our positions are related. As a consequence, if you know the absolute positions of two objects, then you can calculate their relative position. Relative positioning has mainly been used in proximity aware systems (e.g., *Paper 4*, Holmquist *et al.* 1999).

The prototypes I have developed use relative position. We have chosen the term *proximity* to describe the relative position between the user and other people or artefacts. The exact range of what is defined as "in the proximity" of a person varies, depending on the situation as well obstacles in the environment. The Proxy Lady (*Paper 4*) and the News Pilot (*Paper 3*) use proximity to give "proximity based notifications" to the users, in the case of Proxy Lady to support opportunistic interaction.

A concept related to context awareness is "ubiquitous computing" (Weiser 1991). Ubiquitous computing describes a vision of a computer environment consisting of computers, different from those we use today, that is an integrated part of

the user's daily environment. A ubiquitous computer environment differs from the personal computer that is unaware of its context and requires the user's full attention. A ubiquitous computer environment can consist of many different types of terminals, screens and sensors connected through a wireless network. The following quote describes Ubiquitous computing, in Weiser's own words:

> "Ubiquitous computing enhances computer use by making many computers available throughout the physical environment, while making them effectively invisible to the user." (Weiser 1993, p. 75)

In practice ubiquitous computing can be embodied in many different ways. For example, "informative art displays" (Redström *et al.* 2000) are computer displays, mounted on the wall just as a piece of art. Information is visualised in a manner that can function both as art, but it also informs the viewer of something. A display can change the form of the art depending on the traffic of a specific website or when there are a lot of people in a specific room. Using this technique a person can be informed of different phenomena, without abruptly interrupting her current activities. Even though standard PC technology was used to design the prototypes, the use is different from traditional computer use.

2.2 Application platforms

I this section I describe different technologies that are useful in locally mobile situations. The technologies include mobile terminals, operating systems and wireless networks.

2.2.1 Mobile terminals

Mobile terminals can be designed in many different ways, depending on what use situations they target. There are, however, some properties that most mobile terminals for personal use have in common. First, it is important that the boot

up time is short. It is not acceptable if it takes two minutes to boot a mobile terminal, just to check a calendar entry or a phone number in the contact list. Second, most mobile terminals for personal use include some kind of application suite for “Personal Information Management” (PIM). The PIM suits usually include a calendar application, a contact list, a to-do list and a note taking application. Some terminals, but far from all, have networking capabilities built in, or accessible through expansion modules.

The “handheld PC” is basically a mini version of a laptop, including a keyboard and usually a touch screen. The screen is usually wide but not very tall, to be foldable over the small keyboard. The handheld PC is suitable when writing text, for example during a meeting. However, they might be difficult to use if the user does not sit down at a table. “Personal Digital Assistants” (PDA) are small mobile terminals without a keyboard. The screen is usually narrow and tall, to fit in the palm of the user. A pen is used for the interaction with the terminal. To input text most PDAs have some kind of text recognition system. More advanced PDAs can understand hand written text. Most systems, however, require that the user enters text letter by letter in a special predefined form. A “smartphone” is basically a hybrid between a PDA and a mobile phone. Originally, only phone manufactures designed smartphones. However, many PDA manufactures today have, or have announced, PDAs with mobile phone functionality. A smartphone must compromise between mobile phone design requirements (e.g., battery time, size, weight etc.) and PDA design requirements (e.g., sufficient screen size, processor capacity, extendibility etc.).

Norman (1998) suggests the “information appliance” as an alternative to complex devices that can do literally everything. According to Norman, it is difficult to make a user interface that is easy to use if a device has too many different functions. An information appliance is a specialised device that has a more specific use. Just as most kitchen appliances are very good at doing one thing, making coffee for instance, an information appliance is good at performing the specialised task.

Except for the terminals discussed above, there are several terminals designed for more specific situations. For instance, telematics terminals that are designed for use in trucks or in cars or handheld computers that are designed to cope with the rough environment in a factory.

In our projects we have mainly used PDAs that are small enough to carry while being locally mobile. Additionally, we have used standard desktop terminals with large LCD displays to provide the users with suitable user interfaces.

2.2.2 Mobile operating systems and development environments

There are several operating systems for mobile terminals. Four systems are dominant: Windows CE, PalmOS, Linux and the Symbian platform. Besides these there are several other proprietary platforms.

PalmOS has been the most successful operating system for PDAs the past years. Much of its success is probably due to its ease of use and small devices. The operating system is less complex and smaller than the Symbian platform and Windows CE. Therefore, the PalmOS devices have been the smallest PDAs on the market, with a fast user interface and low battery consumption. This is probably the operating system for mobile terminals that most closely resembles the concept of "information appliances" (Norman 1998). The recently announced PalmOS 5, however, makes the PalmOS more complex but also more capable when it comes to multimedia, performance and networking.

Windows CE is Microsoft's mobile operating system. Microsoft distributes several versions of the Windows CE operating system, e.g., Pocket PC 2002 and Handheld PC 2000. Pocket PC 2002 is, just as the PalmOS, a pen-based platform. The screen resolution is set to 240 x 320 pixels and can have (but it is not mandatory) a colour screen. The operating system has several similarities to Microsoft's Windows operating systems

for the PC. Several frameworks, such as MFC[2], ATL[3], COM[4] and Win32 are similar and to some extent compatible in the Windows family and in the Windows CE operating system. Based on the Windows CE platform, two types of smartphones are available. First, "Microsoft Windows Powered Smartphone" is a rather limited version of the Windows CE, while the Pocket PC 2002 Phone Edition, is a full blown Pocket PC 2002 with additional phone functionality. The forthcoming version of the Windows CE operating system, Windows CE .Net, will among other new features incorporate parts of the .Net framework.

Symbian is a joint venture, owned by Ericsson, Nokia, Motorola, Matsushita and Psion. They are building an operating system, Symbian OS, tailored for many different types of mobile terminals, such as handheld PCs, PDAs and smartphones. The Symbian platform is based on an updated version of the EPOC operating system. Each manufacturer that uses the Symbian OS need to design the user interface for their implementation. There is, however, one package that manufacturers can use, the UIQ user interface, which is used in SonyEricsson's P800. The SymbianOS is currently mainly targeted towards smartphones, even if the operating system as such could be used in a PDA.

Linux is an operating system that is predicted to gain some ground in mobile terminals in the future. Currently there are some smaller manufactures that have developed handheld computers specifically to run Linux. One advantage of Linux, except for the fact that it is free to use, is that it is a well known open source operating system, which has a large developer base and possibilities to use the open source packages available today. On the other hand, it is still to be proven if a manufacturer manages to package the Linux system into an end user appealing device that is well intergraded with the desktop.

The PDAs used in my research run on the Windows CE operating system. The predecessor of Pocket PC 2002 was used (Windows CE 2.11). All prototypes were developed using

[2] "Microsoft Foundation Classes"

[3] "Active Template Library"

[4] "Common Object Model"

Microsoft eMbedded Visual Tools (more specifically Embedded Visual C++ 3.0).

2.2.3 Wireless networking

An emerging trend among the mobile terminals is that they become more and more connected. There are several different wireless networking technologies available. One useful way to categorise wireless networking technologies is between long range and short range networks, sometimes called WAN (Wide Area Networks) and LAN (Local Area Networks). Long range networks function over a large area, such as a district, a country or even worldwide. Short range networks work in a much more limited area, maybe with a range of 10 or 100 meters.

Long range networks are telecom operator networks such as the "GSM" network in Europe. The first generation of such telecom networks, called "1G," was analogue cellular networks, e.g., the Scandinavian NMT (Nordic Mobile Telephony) and the American AMPS (Advanced Mobile Phone Service) systems. These networks were deployed in the early 1980s.

The second generation of these networks was designed in the 80s and deployed widely in the 90s. In Europe GSM has been de facto standard, while CDMA has dominated in the US. Both 1G and 2G networks were primarily designed to support speech. However, as data traffic is becoming more and more important, the shortcomings of 2G networks are becoming more severe for the users. For example, the circuit switch design of these networks does not fit a scenario where people want to send and receive much data and be connected for long times.[5] Therefore there is a need for a faster wireless network that is

[5] The circuit switched network model charges for the time the user is connected, which makes it expensive to be connected for long times. Therefore, the user normally chooses to terminate a session after the data or voice has been transmitted, and set up a new session the next time she wants to send or receive something. One problem is that it takes some time to set up the session. Packet switched networks can let the user pay for the amount of information she sends and receives. This makes it possible to be online virtually all the time without having to pay large amount of money for merely being online.

packet switched and suited for both data and speech. These are some of the promises for 3G.

In the mean time the GSM network has been upgraded to support the GPRS (General Packet Radio System) standard, which among others makes the data traffic packet switched instead of circuit switched. GPRS is sometimes called 2.5G. The 2.5G implementation in Japan, NTT DoCoMo's I-mode, has been a huge success, with many users and service providers.

There are two dominating 3G standards: UMTS (Universal Mobile Telecommunications Service) in Europe and Asia, and CDMA 2000 (Code Division Multiple Access) in the US. 3G is a totally new wireless network (it is not an upgrade of 2G) that is more rapid and designed explicitly for data traffic and voice. The development of 3G is delayed and no one actually knows when it is going to be deployed on a large scale. 3G is partially implemented in Japan.

There are today two emerging standards for short range networks: "Bluetooth" and the "Wireless LAN" standard IEEE 802.11b. The two technologies were originally designed for different purposes. Wireless LAN is designed as a wireless alternative to wired LANs and Bluetooth was designed to be a replacement for cable or IR communication between devices.

The 802.11b standard aims to make local area networks wireless, for use with laptops as well as other mobile (or stationary) devices. It provides a bandwidth of 11 Mbit/s (in real use a throughput of 4-6 Mbit/s is normal) and a range of up to 100 meter (depending on the physical surrounding). IEEE 802.11b clients must use wireless base stations to communicate with other 802.11b compatible terminals. The base stations are usually wired to a network and functions as a gateway to that network. There is an "ad-hoc mode" available, which enables peer-to-peer communication between two or more 802.11b terminals if they are within range. However, the ad-hoc mode is not unproblematic. For instance, the user must manually specify an IP-address to use within the ad-hoc network. A faster version of 802.11b, called 802.11g, is backwards compatible with 802.11b and provides a maximum bandwidth of 22 – 54 Mbit/s.

The 802.11g standard is still just a draft, but is anticipated to be set during 2003. There are, however, already products out on the market based on the draft specifications.

The next generation wireless LAN protocols include IEEE 802.11a and the ETSI standard HiperLAN2. 802.11a is a further development of 802.11b, including more bandwidth and improved technical features. The maximum bandwidth is raised to 54 Mbit/s, which also is the case for HiperLAN2. HiperLAN2 is a European standard (owned by ETSI), that seems to loose the battle with 802.11a. They are similar in many ways, including on what frequency they operate (the 5.4 GHz band), modulation techniques and maximum bandwidth. However, there are some differences. For instance, HiperLAN2 defines a media access layer protocol to better support real time critical services, such as voice and video.

The Bluetooth standard was originally invented at Ericsson, but was early out sourced to a standardization consortium that was founded in conjunction with some of the most important actors in the industry. The technology has had some delays, due to problems when implementing the agreed standard into mass produced chips. However, the past year many products have been released. Bluetooth was initially designed to replace cables between devices, such as between a laptop and a mobile phone. Bluetooth was a wireless network for “PANs” (Personal Area Networks). Hence, the range is even more limited, approximately 10 meters, with a bandwidth of up to 723.2 kbit/s. In addition to simple cable replacement functions, Bluetooth enables synchronization functionality, LAN connectivity and service discovery functions. Bluetooth is divided into a core and a set of profiles. The profiles define different types of functionality. Some profiles are pure serial cable replacements, while some more advanced profiles simplifies connection to TCP/IP networks, or synchronization through SyncML. Bluetooth works without base stations. Each Bluetooth chip can act both as a client and a server. The architecture is flexible, but rather complex compared to Wireless LAN.

Short range technologies are especially interesting for local mobility. Short range networking technologies benefits from higher bandwidth, as well as ease of setting up a private network, without any licence fees or traffic costs. The benefits of long range technologies include a higher coverage and ease of deployment (since an operator installed and invested in the infrastructure).

In many settings of local mobility, however, the benefits of long range technologies might be of less importance. First, if a locally mobile person operates in a specific environment, e.g., an office, the investment in setting up the infrastructure for a wireless network will be paid off by the low cost of data traffic. Second, an infrastructure might not be necessary. If communication only is required between terminals, a technology such as Bluetooth will function without any base stations.

Some efforts on mixing short range and long range networking technologies are now being made. These solutions try to mix the benefits from the two types of technologies, and remove the limitations of each technology.

The table below summaries the wireless networking technologies I have discussed above.

	Short range	**Long range**
Bandwidth	732.2 kbit/s - 54 Mbit/s	9.6 – 768 kbit/s
Start-up cost	Cheap bandwidth	Expensive bandwidth
Traffic cost	Expensive to cover large area	Cheap to cover large area
Coverage	Local, hot-spots	Regional, National or Global
Operators	Private, hot-spot operator	Telecom operator
Licence requirement	None	Yes – national license programs
Examples	Wireless LAN (IEEE 802.11a/b), Bluetooth	GSM, GPRS, UMTS, WCDMA, MobiTex

Table 1: Comparison between short range and long range technologies

The choice of technology for supporting local mobility in this thesis was none of the above. We wanted to set up context aware systems, that knew about the relative position of the user. The range of Wireless LAN was too large. Bluetooth seemed to be the best option. However, when the systems were designed, Bluetooth was not yet available. Therefore, custom radio transceivers were developed.[6] More information about the communication technology is available in *Paper 4* and *Paper 6*.

2.3 Summing up

Local mobility is a type of mobility that takes place in a local setting. Locally mobile persons are typically wandering and are commonly engaged in local interaction, either with other people or with artefacts.

Context awareness is a promising technique to support local mobility. Context aware systems adjust their behaviour automatically based on data about its surrounding, or context.

Ubiquitous computers might be able to help overcome the problems of computer use while wandering, while mobile terminals might be suitable in other cases (maybe in conjunction with ubiquitous systems). To network the mobile terminals and maybe even fit them with context aware short-range networking technologies seem suitable.

3. Research approach

This is a thesis in informatics. The discipline of informatics focuses on *the use of IT*, as opposed to IT in itself (Dahlbom 1996). It is a *design oriented* discipline that aims at developing *theory* of IT use (Dahlbom 1996). The focus on IT *use* is

[6] The choice of radio technology was strongly influenced by our colleagues' Hummingbird design (Holmquist *et al.* 1999).

important. This means that we are interested in how IT could be used to help people accomplishing something. In other words, the interest in IT use implies an interest in *design*, i.e., how IT could *change* the way we work or live (to more desirable situations). Because informatics is a scientific discipline, the objective is to develop *theory* of new ways of using IT. Researchers in informatics focus on different aspects of IT use, while some are more interested in empirical studies, others focus on design.

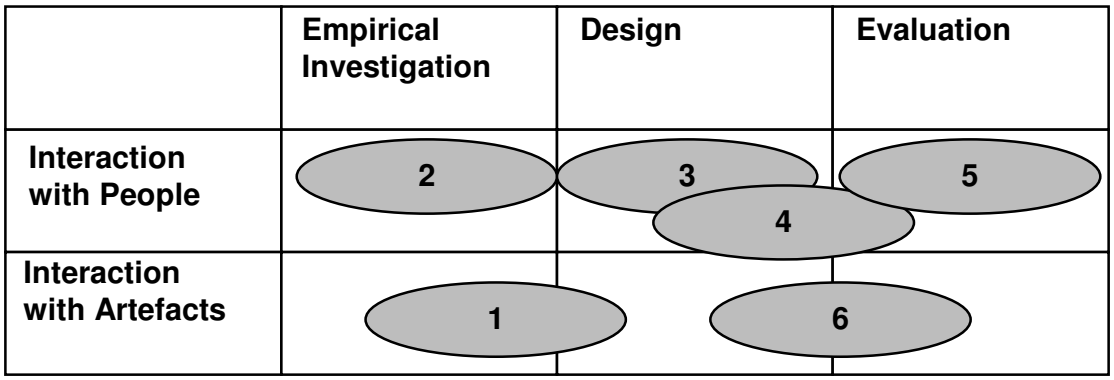
Informatics research with a focus on mobile IT use has been called "mobile informatics" (Dahlbom and Ljungberg 1999). As informatics in general, especially as applied at the Viktoria institute in Göteborg, mobile informatics is more empirically than theoretically informed. Empirical studies seem to inform design more effectively than theory.

Design aims at change. Therefore, it is important to try to understand how changes can be implemented in the domain in focus. Two extremes are to implement change radically or incrementally. The view of change supported in my research promotes the idea of cultivation (Dahlbom and Mathiassen 1993). Cultivation views an organisation as a living organism that is impossible to completely control. Rather than trying to re-design and control everything, cultivation advocates implementation of changes, trying to push the use situation in a specific direction, yet, letting the organisation evolve by itself. Instead of radically changing everything from scratch we should try to improve only those parts that need improvements. Those limited areas of improvements might, however, need to be radically changed. This is also how we should manage the process of change when designing novel IT use for mobile people: keep as much as possible of the current practice, only introduce the specific changes necessary to reach the goal of the design.

The process of informatics research involves three main steps (Dahlbom and Ljungberg 1999): empirical investigation, design, and evaluation of new IT use. In practice, there are often iterations between the steps. In the empirical investigation, the researcher collects and analyses empirical data. The objective is

to come up with useful, novel implications for design of new IT use. In the design step you design novel IT solutions, with a focus on "use." In step three, you evaluate the new IT use situation.

In the figure below, I position the six research contributions of the thesis in relation to the research process of informatics. As discussed above, the focus is on the interaction between locally mobile people and other persons and artefacts.



1. Scalability Through Cultivation: Using Co-Ordination in Design
2. Moving Out of the Meeting Room: Exploring Support for Mobile Meetings
3. Designing for Local Interaction
4. Proxy Lady: Mobile Support for Opportunistic Communication
5. The Use of Bluetooth Enabled PDAs: Some Preliminary Experiences
6. Deskpanel: A Proximity Based Information Panel for Locally Mobile Staff

Figure 3: Positioning of the research contributions.

Theory is not represented as a separate unit in the model above. Rather it is intertwined in each step relying on state of the art understanding of the issues of concern. Also, all steps seek to make a theoretical contribution. For example, based on the empirical investigation of local office mobility we coined the term "mobile meeting," which seeks to capture an important type of informal interaction between mobile people in offices (see *Paper 2*). In the design step, which followed the empirical study, we came up with the idea of "proximity based notification." Finally, based on the evaluations of the new IT use situation, we listed guidelines for the design and deployment of mobile IT solutions based on the idea of proximity based notification. For example,

simplicity seems to be a crucial parameter for the design of such systems.

The research I present in the thesis involves empirical studies conducted at two sites. The first study was conducted at a packaging department of a large Swedish high-tech company (see *Paper 1*). We spent approximately 70 hours at the site, making observations of the personnel. Additionally we interviewed six persons to gain an overview of the organization at the site. The second study was conducted at an IT company owned by the local government of the city of Gothenburg. At this site we also spent 70 hours doing the study.

Both of the investigations studied different instances of local mobility. The field studies were conducted to understand important aspects of local mobility. We conducted the studies using the approach of "quick-and-dirty ethnography," which "…provide[s] a general but informed sense of the setting for designers" (Hughes *et al.* 1994). The use of ethnography for the purpose of design is a much debated topic (Bly 1997, Blythin *et al.* 1997, Hughes *et al.* 1994, Hughes *et al.* 1997, Belotti and Bly 1996), which however has become increasingly common, especially in CSCW (Button and Harper 1996, Bowers *et al.* 1995). Researchers have also experimented with combinations of ethnography and iterative design (e.g., Kensing *et al.* 1998).

The analysis of the field data was inspired by the grounded theory approach (Glaser and Strauss 1967). Grounded theory is basically the theory of no theory. Rather than using pre-selected theories to fit a transcription, theory is built bottom-up in an iterative manner, by categorising and re-categorising the transcriptions. Because our topic of interest, interaction in local mobility, had not been much researched previously, we found it natural to rely on an inductive, empirically oriented research approach. My research cannot be classified as based on grounded theory, but it was inspired by the grounded theory approach.

The empirical studies played an important role in the design phase. They gave us useful implications and a frame of reference for discussions.

The evaluation of the prototypes was carried out at an IT consultancy company in Gothenburg. We let potential end-users use the prototypes during three weeks. We shadowed the users and concluded the evaluation in a workshop. Further, workshop evaluations was conducted at three other sites

Because artefacts aim at changing human practice, they need to be evaluated in some way. The evaluation is ideally performed in the real use setting. However, this is not always possible. For instance, co-operative systems need to be used by a critical mass before it can be evaluated. The researcher might have limited resources, which makes it impossible to evaluate a system in real use. Therefore, a workshop is an effective alternative. The aim of the evaluation workshops we carried out was to get feedback of the design suggestions developed in the research. We also had the opportunity to evaluate the systems in use at a company during a longer period of time.

Let us now direct the attention towards the six research contributions.

4. Research

The research reported here has been performed in collaboration with other researchers, in different projects reported in conferences and journals, six of which are included in this thesis.

The following research papers constitute the thesis:

1. Bergqvist, J. and P. Dahlberg (1999) Scalability Through Cultivation: Using Co-Ordination in Design. In Scandinavian Journal of Information Systems, Vol 11, pp. 137-156.

2. Bergqvist, J., P. Dahlberg, F. Ljungberg and S. Kristoffersen (1999), Moving Out of the Meeting Room: Exploring support for mobile meetings. In Proceedings of

The Sixth European Conference on Computer Supported Cooperative Work, ECSCW'99, Edited by Susanne Bødker, Morten Kyng and Kjeld Schmidt pp. 81-98, Copenhagen, Denmark.

3. Redström, J., P. Dahlberg, P. Ljungstrand and L.E. Holmquist (1999) Designing for Local Interaction. In Nixon, P., Lacey, G. & Dobson, S. (eds): Managing Interactions in Smart Environments, pp. 227-238. Springer-Verlag

4. Dahlberg, P., Ljungberg, F. and Sanneblad, J. (2001) Proxy Lady: Mobile Support for Opportunistic Communication. In Scandinavian Journal of Information Systems, Vol 14., pp. 3-17.

5. Dahlberg, P. (2003) The Use of Bluetooth Enabled PDAs: Some Preliminary Experiences. Submitted for publication.

6. Dahlberg, P. and J. Sanneblad (2000) Desk Panel: A Proximity-Based Information Panel for Locally Mobile Staff, In Proceedings of NordiCHI'2000 - The First Nordic Conference on Computer Human Interaction, Stockholm, October 23-25, 2000

In the *Paper 1*, "Scalability Through Cultivation: Using Co-Ordination in Design", we present an empirical case study of the packaging department of a large manufacturing company, which recently had undergone extensive growth. Our focus is on how to design for such a growth from the point of departure of a cultivation perspective of change. As opposed to radical approaches to change, the cultivation perspective stresses that as little as possible should be changed when designing new IT use. In the analysis of the empirical data of the study, we applied coordination theory (Malone and Crowston 1994). The personnel at the department we studied were always "on the run" locally, however they rarely left the plant. The main contribution of this paper is an extensive discussion of how to "scale up" a locally mobile work practice.

"Moving Out of the Meeting Room: Exploring support for mobile meetings," *Paper 2*, is also an empirical paper that coins the term "mobile meetings" and outlines design implications for such meetings. A mobile meeting is a short face-to-face meeting with two or more participants, which typically takes place at someone's office or a corridor. The meetings are, compared to formal meetings, informal but work related – similar to work related informal communication. Mobile meetings is a type of local mobility. The use of IT in these mobile meetings was very rare. In fact, technology was used only when absolutely necessary, and in these cases the technology was commonly interfering (in a negative manner) with the meetings. Based on the empirical findings, we in this paper sketch implications for design.

Paper 3, "Designing for Local Interaction", uses three previous design cases to draw some generic conclusions for design of IT support for local interaction. All designs concern local mobility and are (to different extents) aimed to support interaction, either between people or between people and artefacts. The prototypes include "the Hummingbird," which is a device that aims to support group awareness, "the generalized Hummingbird" that includes awareness of artefacts in the proximity and "the NewsPilot" which is a design aimed to support creative discussions among locally mobile journalists. The discussion includes the problems of defining proximity only using the distance and the use of proximity as a constraint for information distribution and filtering.

Paper 4, "Proxy Lady: Mobile Support for Opportunistic Interaction," describes Proxy Lady, a mobile application that is based on the results from the empirical papers. This application aims to support "opportunistic interaction." Opportunistic interaction is a type of local interaction that takes place when two (or more) parties accidentally meet each other and get the opportunity to interact. Proxy Lady is intended to be used among people in face-to-face settings, typically when being locally mobile. Proxy Lady seeks to support mobile meetings by implementing the design implications from previous papers.

Proxy Lady lets the user enter and store items (e.g., to-do items) related to a person. When that person enters the user's proximity she it notified with the item. A first user feedback is achieved through a workshop with potential future users.

In *Paper 5*, "The Use of Bluetooth Enabled PDAs: Some Preliminary Experiences," I describe some preliminary use experiences of Proxy Lady. There are not very much practical experience on the use of applications that rely on the Bluetooth technology. This paper reports from user trials of Proxy Lady (built for Bluetooth). The use of the system is discussed, including privacy issues, suitability compared to other communication channels and possible future directions for this type of software support. Even though the paper focuses on the use of Proxy Lady, some results might be possible to generalize to other types of systems for Bluetooth enabled PDAs.

In *Paper 6*, "Desk Panel: A Proximity Based Information Panel for Locally Mobile Staff," we describe the system Desk Panel, which is a proximity based information panel helping locally mobile people to quickly get an overview of centrally stored information such as e-mails and tasks. Desk Panel shows the information on large wall-mounted displays. Each user has a transponder to notify the Desk Panel system that she is in the proximity of the display. Using the ID from the transponder, the Desk Panel system retrieves and displays the relevant information for the user. According to user trials, Desk Panel has the potential of being a useful tool for locally mobile staff. This paper outlines the rationale, design, implementation and user trial of the system.

5. Results

The research task is to investigate how work related locally mobile interaction can be supported using context aware applications. To answer the question, I have gone through the

literature in the area, participated in empirical studies of mobility, elaborated on design ideas, based on which we have developed and evaluated applications. In the empirical studies, we collected data about the nature of local mobility in organizations. We analysed the empirical data to understand local mobility and to come up with novel, but yet empirically anchored design conceptualisations. There are different types of results of these research activities, in particular design conceptualisations and suggestions, but also theoretical claims concerning local mobility. Let me now summarize the main results.

There are two main theoretical results of the thesis: "Scalability through cultivation" and "the mobile meeting." One result of the thesis is the idea of "scalability through cultivation" as a means to manage the scaling up of work processes (in our case, mobile work processes in a plant, see *Paper 1*). Dahlbom and Mathiassen (1993) introduced cultivation as an approach to, and perspective on organizational change. From a cultivation perspective, they argue, the organization can be viewed as a living organism that you best change incrementally. The organization evolves steadily and the task of the systems developer is to guide the evaluation by means of small interventions of new IT use. In *Paper 1*, I based on the concept of cultivation and coordination theory, introduce the idea of "scalability through cultivation" as a novel perspective on how to scale up (mobile) work processes. Our proposal is, simple put, that the co-ordination mechanisms between operations (not the operations as such) should be redesigned to decrease the risk of disruptions.

Another result, which is also based on empirical studies of mobility in organizations, is the concept of "the mobile meeting" that we introduce in *Paper 2*. The mobile meeting is a work related type of informal communication between mobile people in office environments. Compared to "informal communication," as described in the CSCW literature (see, for example, Kraut *et al.* 1990), the mobile meeting is clearly "bracketed" from other organisational activities; there is a work related agenda and only

people concerned become involved. This way the mobile meeting differs from common definitions of informal communication in the CSCW literature (e.g., Kraut *et al.* 1990). We found the mobile meeting to play an important role in the work at the office studied. This result is a theoretical contribution, based on empirical investigations.

The main focus of the thesis is the applications we have developed and evaluated. The design of these have been much influenced by the empirical studies and discussions mentioned above. The main application of the research is called "Proxy Lady." This is a novel context aware application that uses the proximity of people as a means to support opportunistic interaction (see *Paper 3*, and *Paper 4* for a discussion of relative positioning as a resource when designing mobile IT). The user of Proxy Lady can associate other users with notes and other "information items" (e.g., a note about something you want to discuss with a particular person when you meet). The application scans for other users in the physical environment, and when someone on the list is nearby it notifies and makes the information item easily accessible. This type of "opportunistic interaction," to use the conceptual framework introduced by Fish *et al.* (1990), has not been supported with IT applications previously. A related result is the evaluation of the use of Proxy Lady in work situations (see *Paper 5*). According to the study, the task domain Proxy Lady seeks to support is recognized and considered important.

The final result is the "Desk Panel" application, which we developed based on the empirical studies (see *Paper 6*, and *Paper 2* for elaboration on the empirical studies). Desk Panel offers novel support in that it lets mobile people easily access and view emails and other information on large screens placed in suitable places in the office. Desk Panel is in a way the opposite to the idea of the handheld computer, where the user brings a small computer and views information on the screen. The idea of the Desk Panel was to use computer artefacts placed in the environment. The type of communication support that Desk Panel offers is also novel. The evaluation of the system indicates

a positive attitude towards this type of system. Some concerns included privacy issues, and problems when too many users were in the proximity at the same time.

6. Discussion

In the discussion below I wish to bring to the fore two issues that have been important in my research. First, I wish to discuss the concept of context awareness, which has been used much recently, and in which some have put much faith. Second, I want to discuss the cultivation approach that we used in *Paper 1*, and which is an important part of the empirically oriented research approach on which this type of informatics is based.

6.1 Context awareness in local mobility

Context aware computing has been around for some years in research, and has recently gained some ground in the commercial world as well. Most systems in real use settings utilise “simple” physical context properties, such as location. Different physical properties are easy for a computer to measure using a variety of sensors. For instance, it is easy for a system attached to a lamp to determine if it is dark outside, and if there is something (someone) moving within its proximity. Therefore, we can now buy lamps that are switched on only when someone is moving close to the lamp. Further, there are several different technologies that a computer system can use to determine the position, e.g., GSM positioning and GPS. The positioning systems very seldom make errors when determining the position. Position is such a well-defined property that is easy for a computer to determine.

In our field of research, researchers want to take one step further and explore more complex properties of the context to make computers even smarter. Some claim that "the mental state of the user" should be used to make applications adjust to the user's needs at each time (Schmidt *et al.* 1998). Even though it might be a desirable vision, it is still unclear how such awareness should be accomplished. By using sensors most physical properties can be measured, but to extract conclusions on a higher level from those properties are difficult. Many assumptions seem to be risky. For instance, if a cellular phone is lying still, one might think that it is on a table and that the user is in a meeting. Therefore, a developer might think that it would be suitable to lower the strength of the ring signal. However, the user might have forgot the phone in the meeting room. The correct behaviour could in this case be to raise the ring signal even more. But, in some situations (e.g., during the meeting) the right decision would indeed be to lower the signal. It is, thus, impossible in this case to know what action that is the correct one by just using simple physical properties. The application could be made smarter by, for instance, combining the movement sensor with the user's calendar and check if a meeting is scheduled. Designers must be careful in what assumptions that can be drawn from the context. If the behaviour does not work often enough, the system will just be annoying for the user.

We have encountered some problems with one of the context aware systems we developed: Proxy Lady (*Paper 4*). The networking technology that is used by the Proxy Lady system, short range FM radio technology, can transmit radio waves through walls and other obstacles. When two Proxy Lady terminals could communicate, we assumed that the Proxy Lady users were close to each other, in the sense that they could see each other or that the other user at least was not further away than "around the corner." In a strict manner the two users are always close to each other: The range is limited, hence, if the devices can communicate, they must be close. However, since the signal goes through walls, there might be situations where it

is impossible for two persons to interact. They might be on different floors in a building, or there might be a wall without doors between the users. Thus, even such a simple property as proximity of persons is really difficult to accomplish without any problems. In our evaluation we encountered few such situations, but it is still an important to note that the use of sensors can sometimes gives applications unintended functionality.

The point here is not that we should avoid context aware systems. On the contrary, I believe that the use of context in mobile systems have a bright future. However, we must be careful on how to use the input we get from the context. If we draw faulty conclusions from the context the behaviour of the systems will be incorrect. But, if we use it right it will be very useful.

6.2 Don't obliterate, Cultivate

In *Paper 1* we apply cultivation (Dahlbom and Mathiassen 1993) as an approach to implement new technology and new work practice in an organization. This paper is the only case of the thesis where the design was specifically built based on one work setting in one organization. However, the cultivation approach can easily be used in most cases when adopting new technology. The other papers in this thesis are all examples of cultivation, even though they report from different stages of the design process.

The use of cultivation to improve work practice can be compared to radical approaches, e.g., Business Process Reengineering (Hammer 1990). Instead of obliterating the old way of doing things, the cultivation approach tries to be as gentle as possible to the current way of working and only change minor, non functioning parts, letting the organisation evolve as much as possible by itself. Radical approaches, on the other hand, focus on totally new ways of working, for instance, by re-building the business processes in an organization. The point is

that old, maybe irrational work practices should not be preserved, only because they functioned earlier. Naturally, that is true, but implementing radical changes is usually problematic, why a cultivating approach might be suitable anyhow.

The nature of our research makes it impossible to redesign everything. A small system for information sharing, for instance, will not radically change everything. Therefore, a radical approach is really not an option. When looking at "generic applications," such as the Proxy Lady (*Paper 4*) or the Desk Panel (*Paper 6*) it is not up to the developer to carefully implement technology, in conjunction with new ways of working in specific, well defined processes. Rather, the technology made available to users who start to use it in the way they find best. If the task is to support common everyday tasks, e.g., to support communication, it is very difficult to radically change how all communication is conducted. Rather, new technology becomes an intertwined part of the new, cultivated, way of communicating. Hopefully, the new technology can assist in the communication, but it would hardly obliterate the old way of communicating. Rather, using new technology the way of communicating is cultivated – maybe in a way that was not intended by the designer at first.

This approach is rather common in our field. Even though many of us aim to be innovative, the result is still cultivated situations for the users: They will go on with their life pretty much in the same way they did before. Maybe, they will use a new piece of technology that can make some things a bit better, or at least different. But it will not radically change their way of life. And that is probably just as good!

6.3 Future directions

Clearly, there are many issues that have not been addressed. I would suggest the following future directions based on my research:

- Further development of Proxy Lady. Even though the system has been tested in real settings, the process of adopting new technology gives ideas of new types of use. I would suggest that Proxy Lady should be refined and redesigned, to implement and evaluate new features. Those features include notification of artefacts and use of wearable computers just to mention a few ideas.

- Further development of the Desk Panel. The panel is only an early prototype. The use gave some directions on future work. However, both technology and use ought to be further developed to get a better understanding of what this type of technology can do (good or bad) for people in different settings.

- Apply the designs to other settings. The prototypes have been evaluated in a rather narrow focus on professionals in local office settings. It is unclear how the devices would work in other types of settings.

- Further exploration on mobility. Even though many studies are being conducted on mobility we do not fully understand how people are being mobile in all different settings. Clearly, more empirically informed research would improve our understanding of mobility in different situations, which in turn would improve the design of new applications.

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Section Two

First Paper

Scalability through Cultivation: Using Co-ordination Theory in Design

Jens Bergqvist and Per Dahlberg

Abstract

The objective of this paper is to discuss how to use Information Technology to enable the staff at a mission-critical order packaging department to cope with a drastically increasing scale of operation. To reduce the risk of interrupting the production, a cultivation approach is adopted. We use co-ordination theory to analyse the current work setting and present a design proposal. The basic building blocks of the analysis and the design are co-ordination mechanisms. This facilitates the understanding of today's way of working, as well as the design of a new setting, enabling the department to cope with the larger scale of operation. The underlying approach for the change process is cultivation, which is a softer, less disruptive approach compared to more radical methods for organisational change. Based on the results, we argue that it is the co-ordination work that is lacking, not the actual productive work performed. Even though co-ordination theory has been criticised for being difficult to apply in practice, we find that it is indeed fruitful to use in this real-world case. The cultivation approach facilitates a design that

allows implementation of changes without disrupting the throughput at the department.

1. Introduction

What happens when a small-scale department suddenly has to deal with an annual growth in production of well over fifty per cent? Is it at all possible to preserve the way of working that has developed over the years? If so, is it possible to use Information Technology (IT) to do this?

We have conducted qualitative research at a mission critical packaging department of a large Swedish company that is experiencing a growth rate of this magnitude. In this paper we will discuss how to enable the staff to cope with the increasing scale of operation. In particular, we will explore the important aspect of scaling up the current work setting and present a design strategy that makes it possible to transform non-scalable work into scalable work. The objective is interesting from a business perspective as well as a research perspective, since the company is in need of an evaluation of today's work practice and design suggestions for a future work practice capable of coping with the growing scale of operation.

The department has been, and still is working very well. However, the production is growing rapidly e.g. the anticipated growth in 1999 alone is 100%. The growing throughput in the factory is giving the order packaging department two kinds of problems: (1) the number of important events that must be monitored and controlled has grown and they are becoming difficult to track. (2) The old way of working is not efficient enough: they are already working at full capacity and are unable to increase the throughput.

The workers as well as the management find today's way of working satisfactory, but they fear that the rapid growth will cause severe problems and realise that it is time to "do something" in order to prevent a total breakdown in delivery

precision and packaging quality. We use the term “scalability” to denote the ability of a work practice to cope with an increasing workload.

Because the work practice today is satisfactory we choose to base our analysis and design on the cultivation approach (Dahlbom and Mathiasen 1993). This approach views the organisation as a living organism, constantly changing and evolving. By changing some of the computational tools and procedures in the current work practice we attempt to guide the evolution of the department in a beneficial direction. This approach contrasts against radical approaches, e.g., BPR (Hammer 1990), where you re-design the entire work practice.

Since we will change only parts of the work, we are interested in the interfaces between different parts of the work practice. We use co-ordination theory (Malone and Crowston 1994), as described in the CSCW field to investigate these interfaces. Furthermore, according to Schmidt (1994) a means of articulating work is not provided via the work itself; it must be explicitly communicated. If a work setting is small enough, the articulation may be handled in an ad-hoc fashion, but as the work setting grows, and therefore becomes increasingly complex, it is essential to provide adequate support for the co-ordination of activities. In order to enable scalability we must supply that support.

Thus, our objectives are to investigate to what extent the use of co-ordination theory, in conjunction with a cultivation approach, supports (1) the understanding of a work setting and (2) the design of work practices capable of coping with a higher scale of operation.

The paper is organised as follows. First, we discuss the concepts of cultivation and co-ordination. After a brief discussion of the site and method we report the results from the field study and present our design proposal. Finally, we discuss the results leading up to the conclusion.

2. Cultivation

The nature and importance of cultivation in organisational change and IT development are best described in the words of two of the authors who have introduced cultivation into the Informatics community:

> "Construction and cultivation give us two different versions of systems thinking. Construction is a radical belief in our power to, once and for all, shape the world in accordance with our rationally founded goals. Cultivation is a conservative belief in the power of natural systems to withstand our effort at design, either by disarming them or by ruining them by breakdown." (Dahlbom and Janlert 1997, p 7)

> "To the extent that organizations have a life of their own, as long as they evolve, grow and learn by their own power, then organizations have to be cultivated rather than constructed, and the development of computer technology use in organizations will be a matter of cultivation rather than construction." (Dahlbom and Janlert 1997, p 111).

At its most basic level, cultivation states the following: do not change, and thereby upset, an organisation more than what is absolutely necessary to accomplish the task at hand (Dahlbom and Mathiassen 1993, Dahlbom and Janlert 1997). Construction on the other hand assumes that a new well functioning organisation can be designed and implemented without taking the current situation into account. A prominent example of this approach is Business Process Reengineering where the old organisation should be obliterated in favour of the new (Hammer, 1990).

How would cultivation apply to the situation we have studied as opposed to construction? Consider this simple metaphor of a gardener nursing a young tree. As the tree grows ever bigger it evolves features that are undesirable. Unless these features are untreatable the gardener does not cut down the tree and plant a new one (that is construction). Instead he prunes it,

eliminating the defects and allows the tree to continue to grow and evolve. Alternately, he ties up branches to make then grow in the preferred direction. If the gardener's judgements were right the tree will be healthy and display the desired features. What the gardener does is cultivate the tree, that is, he trusts the innate abilities of the tree and allows it to grow on its own, only taking on a guiding role rather than a more controlling one.

Viewing a work place from this perspective implies that the complex interactions of the current situation must be well understood in order to judge which parts are working and which parts are not. Only the badly functioning (here: non-scalable) parts should be addressed with new ways of working. It is much akin to how the evolutionary approaches (Dahlbom and Mathiassen 1993) work, but in a more controlled fashion. Cultivation means to promote guided evolution in the work place. The guidance is needed to prevent the organisation from "growing the wrong way" and make sure that, for instance, a single department does not evolve into a state that is counterproductive to the organisation as a whole.

This approach contrasts rather sharply with more radical theories of organisational change, which state that organisations should be reshaped completely, top to bottom, in order to meet new demands (Hammer 1990). The point of using the cultivation approach is to keep well functioning parts and (within reason) build upon those parts. Basically it is a way of making sure you do not throw the baby out with the bath water, which, according to Gallier (1997), is more likely to happen using a radical approach such as BPR as presented by Hammer.

To accomplish the identification and separation of well working parts from badly working parts, a means of analysing the interdependencies between different aspects the work setting is needed. Thus we turn to co-ordination theory.

3. Co-ordination

We are constantly co-ordinating our day-to-day life. This is done in different fashions ranging from the casual "I put the keys on the table, honey!" to formally filling out papers. This is clearly an interesting phenomenon and it is comprehensively investigated in the literature. Coordination is a central issue in the organization of people and tasks (cf., Mintzberg 1983, Thompson 1967). It is therefore a central issue in CSCW (e.g., Schmidt and Simone 1996, Malone and Crowstone 1994).

A simple definition of co-ordination is "…managing dependencies between activities" (Malone and Crowston, 1994, p. 87), i.e. if two or more activities are dependent upon each other they must be co-ordinated in order to manage the interdependency between them. According to several studies (e.g., Schmidt 1993, Carstensen and Sørensen 1996) the resources needed to co-ordinate the work increases when the work setting grows. In smaller settings a more ad-hoc means of co-ordinating the work might be sufficient, but when it grows the need to support co-ordination increases. Thus, to investigate co-ordination, we will focus on the interfaces between the work activities rather than on the activities as such. We now discuss the concepts and terminology used in the analysis.

3.1 Articulation Work

In a co-operative work setting the actors share the same resources, that is, they are mutually dependent on each other when carrying out their activities. The co-ordination of these interdependencies can be managed through the work itself or through explicitly communicating the current state of the work to all affected parties.

Strauss (1988) introduced the concept of articulation of work. In the CSCW field, Schmidt and Simone (1996) use the terms articulation work and co-operative work to make the distinction between co-ordination work and "all other" work. In a

work setting the workers manipulate, control and monitor objects according to certain rules. These rules are the procedures of work. This set of objects and procedures is denoted the workers field of work. Some co-ordination of activities can be managed indirectly through the field of work and in other cases it must be explicitly communicated.

Dix and Beale (1996) introduce a framework for CSCW (figure 1) where they make a distinction between direct communication and communication through an artefact. Direct communication is when two persons are communicating with or without the use of technology, e.g. face-to-face, e-mail or telephone. Communication through an artefact is a more indirect way of communicating as information is mediated through an artefact.

The framework for CSCW complements that of Schmidt and Simone. Co-operative work is work performed by several individuals in a common field of work. Some co-ordination is achieved by the feed-through when manipulating artefacts in that field of work, e.g., a paper in an in-tray signals the initiation of a different action than the same paper placed in an out-tray. Articulation work is the direct communication used to enhance that co-ordination, e.g., a colleague telling another that a certain paper in the in-tray should in fact be treated as if it were in the out-tray.

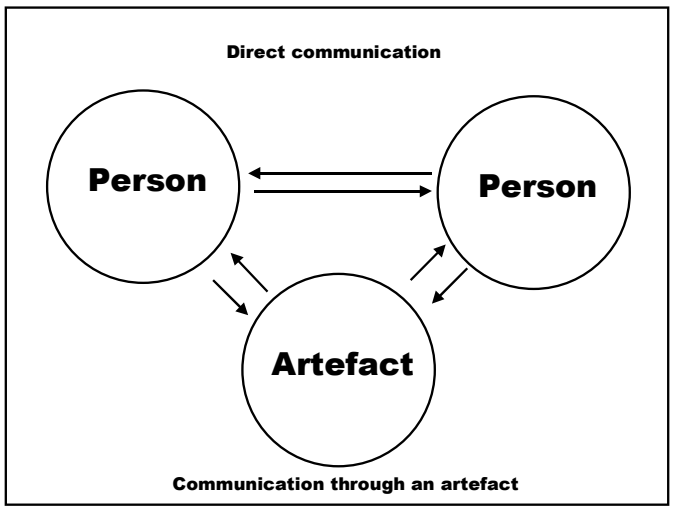

Figure 1: The Dix and Beale framework for CSCW

3.2 Co-ordination Mechanisms

When a work setting becomes more complex some form of support is needed to facilitate the co-ordination of work (Schmidt 1993, Carstensen and Sørensen 1996). One way of reducing the complexity of articulation work is to employ Co-ordination Mechanisms (Schmidt and Simone 1996, Carstensen 1996). A co-ordination mechanism is an artefact that is used to help actors to co-ordinate their work. It provides a protocol that defines the possible means of articulating the work, and it also makes the actors less dependent on direct communication, since the co-ordination mechanism can serve as mediator of the articulation. It follows that by using co-ordination mechanisms we are able to articulate the state of work by communicating through an artefact. This possibility is not obvious in the Dix and Beale framework. However, it is possible to extend it to accommodate this (figure 2).

In figure 2 the first notion of articulation work is still direct communication, explaining the state of work to others (1). The co-ordination achieved by manipulating objects in the common field of work is denoted “co-operative work” (2). However, by using co-ordination mechanisms, objects existing outside the common field of work are introduced to reduce the complexity of articulation work (3). Hence, the Dix and Beale notion of communication through artefacts is either co-operative work, or articulation work depending on the function of a specific artefact.

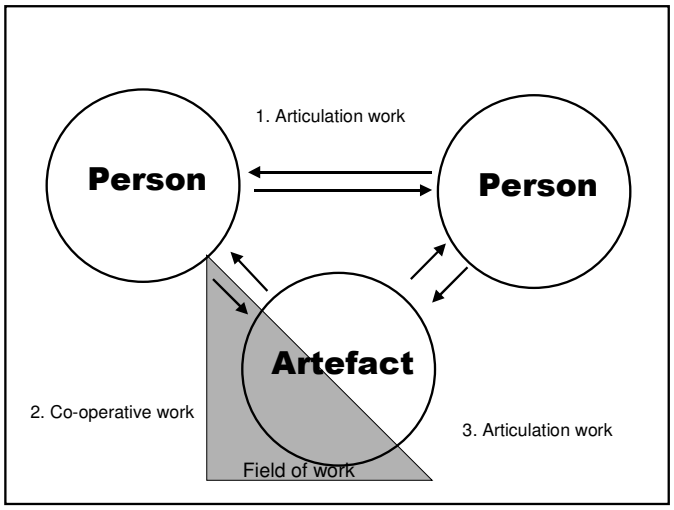

Figure 2: Extended framework for CSCW to understand Co-ordination mechanisms

4. Research Site and Method

The packaging department where we conducted the study is part of a modern manufacturing site for high technology equipment. The total number of employees at the manufacturing site is approaching 1400 and roughly 25 are working at the department in focus. The site is part of a global enterprise with manufacturing sites and customers worldwide.

The personnel work in two shifts, sometimes even three, and also weekend shifts during workload peaks. The shifts overlap one hour, meaning that the first shift always has time to transfer ongoing tasks to the new shift and discuss problems and tasks and events out of the ordinary.

4.1 Method

We began the project by doing a field study to gain knowledge of the current work practice at the department. The study lasted for two weeks, and we spent approximately 70 man-hours at the

site. The field study was conducted using "Quick-and-Dirty Ethnography" (Hughes et al. 1994), which "…provide[s] a general but informed sense of the setting for designers." (ibid) The use of ethnography to gain knowledge of the work practice has been extensive in the CSCW field (c.f., Button and Harper 1996, Bowers et al. 1995). Ethnography for the purpose of designing IT, rather than solely for the purpose of understanding the current work practice has been explored by, for instance Bly (1997), Blythin et al. (1997), Hughes et al. (1994, 1997) and Belotti and Bly (1994). It has also been combined with an iterative intervention approach (e.g., Kensing et al. 1998).

At the beginning we conducted semi-structured interviews (Patton 1990) with administrators, such as order-clerks, as well as with some of the managers at the department. Our objective was to get a quick overview of the tasks conducted within the department, as well as an overview of the organization of work. A total of six interviews were conducted, each ranging from fifteen to sixty minutes in length. Subsequently, we shadowed workers with different roles and tasks and asked questions about what they were doing and why. Detailed notes were taken during the study.

We applied the co-ordination mechanisms framework to the field data to identify issues for further study. More issues became apparent when we analysed the field data, using a grounded theory approach (Glaser and Strauss 1967). The analysis started during the second week of the study and was continuously refined for several weeks during multiple sessions.

In order to arrive at a design proposal, we further analysed the identified issues from a co-ordination theory perspective in search of similarities and common problem causes. When this was accomplished we broadened our view is somewhat to investigate the relationships between the issues and how a change in one issue would affect another. In this theoretical experimental fashion we arrived at a well-rounded and consistent set of design issues that compose a design satisfactorily supporting the scalability of the work practice.

The cultivation approach was used throughout the process, in conjunction with previously described methods. The choice of methods and theory is based on the cultivation approach. The co-ordination mechanisms framework helped us focus on the interfaces between work activities and develop new IT support.

The design proposal was evaluated in a workshop where we presented and discussed the results. The participants also filled out a qualitative feedback-form. Nine months after the project, we conducted a semi-structured interview with a department manager. The objective was to establish whether the design suggestions had been implemented and if a cultivation approach had been applied during the change process.

5. The Work Practice

Figure 3: A view of the order packaging department.

The department consists of three distinct areas. The administrative area (not shown in Figure 3) where all the clerks

and other administrative personnel reside, the product packaging area where the first stage of the packaging takes place and the order packaging area where the second and final stage of the process is conducted. There are also several external plants, where some products are manufactured and stored.

In order to structure the description of work at the order packaging department we have divided this section into two parts. First, we describe important co-ordination mechanisms in use and second we show how a single order moves through the department, describing the main processes and highlighting important issues.

5.1 Co-ordination Mechanisms

During our study we have identified two artefacts central for supporting co-ordination work, the work order and the board. The importance of these artefacts will become evident in the description of work below and in the discussion following it.

5.1.1 The Work Order as a Co-ordination Mechanism

A work order is a set of papers stapled together representing the customer's order throughout the packaging process. It consists of two E-orders, one of which is the actual delivery note and the other is an administrative tool. Furthermore, there is a T-order, which is a bar code version of the E-order for internal use and finally a map of the work floor. The work order is a co-ordination mechanism that supplies the operative information a worker needs to perform his work. By existing as only one copy, it insures that only one worker handles an order at any given time, making the processes sequential. Thereby the constraints of the packaging process are enforced. In conjunction with the board it also regulates the transfer between the product packaging process and the order packaging process as elaborated on in section 5.2.

5.1.2 The Board as a Co-ordination Mechanism

Figure 4: The board, without order lists. On the left-hand and right-hand sides are the paper tray columns used both by order packaging and product packaging for storing work orders.

The board consists of four different parts: a large notice board and three columns of paper trays. The notice board contains listings of all current orders. These are posted to make the workload and the status of each individual order visible to all. This is an example of what Dourish and Belotti (1992) refer to as explicitly generated information for facilitating awareness. This list supplies the workers with enough information to set the pace of work during the week. The board is a co-ordination mechanism that facilitates awareness. The awareness function must be supported in the future work practice. A few weeks after the field study was completed, we returned to the order packaging department for other reasons, and discovered that there were no longer any listings posted on the board. The number of orders had grown so much in those few weeks that the lists no longer fitted on the board (figure 4). The awareness

function of the board had already been diminished due to the lack of scalability of this particular co-ordination mechanism.

The first column of paper trays is where work orders are placed when first issued from the planner, the second column is where the work order is placed when the product packaging process is completed and the third column contains faxes of E-orders with stock information from external plants. The placement of a work order informs the workers as to whether the product packaging department or the order packaging department should process the order. The board is a co-ordination mechanism that (in conjunction with the work order) co-ordinates the transfer of products between processes, as well as enforces the prerequisite constraints (Malone and Crowston 1994) of the packaging process.

5.2 A Work Order's Journey

We will now describe how a work order moves through the order packaging department. We focus on the work order for the purpose of making the different processes explicit in order to make the co-ordination mechanisms visible and thereby making it possible to identify the co-ordination work associated with them. The main processes are the product packaging process and the order packaging process.

5.2.1 Product packaging

A clerk receives orders from customers and enters these orders into a central computer system, registering delivery date, customer information, etc. Every week another clerk, the planner, sorts the orders in the system by giving priority to the most urgent orders and orders from the most important customers, to ensure that these are processed and shipped quickly. This results in a chronological list of what orders to package each day of the week. Another clerk prints the list, and

for each item (i.e., order) in the list, a separate work order is compiled and printed.

The journey of a work order begins when the clerk places it in the product packaging tray column. Product packaging is where the individual products are wrapped in carton, together with cables and other standard accessories. The work orders are stored in chronological order, with the one with the closest delivery date in the top-most tray. When a product packager does not have any task to perform, he goes to the board and checks the tray column to obtain a new task, i.e., a work order to process. He takes a work order from the top tray and checks what kinds of order items are listed on it. The product packaging department is split into two parts, each responsible for packaging one of two different product families (A and B). If the worker finds any order items that should be packaged by his department he takes the work order to his work desk and starts to package the products. For each order item there is an index number, indicating what kind of accessories should be enclosed with the product. Some clients want manuals, some just need a set of cables and some want no accessories at all. Each carton is labelled with bar codes representing the product number and index number.

The packaged products are stored in an interim storage area. The location is marked on the map included in the work order, and the order items packaged are marked as well. Because there is a large number of combinations of accessories there is also a correspondingly large number of indices. The products are therefore stored in the interim storage area as per order and not as per product number and index number. The growing throughput in the department has made it difficult for the product packaging personnel to fit all the processed products ready for order packaging into the area reserved for interim storage. Often they place the products in an adjacent floor area instead. They mark the spot on the work order map with an ”X” and jot down a nearby shelf number next to the mark. It is clear that this work practice will not be able to cope with the growing workload. This is a key scalability issue.

Depending on whether there are any products from the other product family to package, the product packager puts the work order back in the product package tray or in a tray in the next column. If he chooses the second option the work order is passed on to order packaging. This choice is an indication of both the transfer co-ordination function and the prerequisite constraints enforcing function of the board.

5.2.2 Order packaging

At the order packaging department, the assignment of tasks works in a similar way. An idle order packager goes to the board and checks the order packaging trays for work orders to handle. First he checks the list of order items to make sure everything is ready (i.e., that everything requiring product packaging has in fact been processed). If there are any products handled at another plant (members of product family C), he checks the E-order faxes in the third tray column. An E-order fax contains a parcel number for each order item packaged at another site. If he cannot find any such fax he puts the work order in a special tray with a post-it sticker showing what product is missing. The order will not be order packaged until all order items from product family C are packaged. (Another example of enforcing the prerequisite constraints) The management has decided that the product packaging should be completed, but not the order packaging if there are order items missing from the external sites. It sometimes happens that products are stored in the interim storage area for weeks. The process of co-ordinating the packaging when there are products manufactured and packaged at external plants is a problem. This is an issue we identify as important for making the work practice scalable.

To facilitate the order package work and ensure good quality a small handheld computer is used. The device works very well, and has increased the quality dramatically, i.e. the number of packaging errors decreased. However, the functionality of the handheld computer as well as the connection to the central computer systems is very limited. The bar codes on

the T-order are used to scan all order items, quantities and other order information into the handheld computer. There are two bar codes for each order item (item number and quantity) and also bar codes for the order as such (date, order number, customer number etc).

The packager examines the order items and tries to estimate whether the order is to be shipped in one or more parcels. If the order turns out to result in more than one parcel he should try to split it up with the sequence of the order items on the E-order in mind. However, this is not always the case, since he also needs to optimise the space available in each parcel. It is common practice that products that formally should be shipped in parcel number two are in fact packaged in the first parcel and vice versa in order to save space. The rules regulating this matter are flexible and the order packager uses his acquired knowledge of ”how things are done” to find a satisfactory compromise between the rules and the need for saving space.

He decides what order items to package first and checks the enclosed map to find out where the products are stored. He selects a free space on the floor area reserved for order packaging, and there he gathers enough products to assemble a parcel. For each product he scans the product number bar code. The handheld computer warns the packager if he forgets to package a piece of an order item. It is possible since both what products to package and their quantities are stored in the computer. However, if the packagers accidentally package too few items, the handheld computer will not sound the warning until the packager tries to dock the handheld computer.

The order packaging personnel spend very much of their time searching for the items to package. This is due to the fact that the interim storage area is no longer large enough to accommodate all the products that should be stored in it. This has two negative effects: First, all products are not stored in their appropriate shelves, but are instead placed in an adjacent floor area and its approximate position is marked on the map that is included in the work order. Second, it means that the floor area available for the actual order packaging process is

diminished. To sum it up, we discovered that not only does the increase in interim stored products make it more difficult to find the products listed in an order, but it also hampers the order packaging process itself by reducing the available floor area usually reserved for this process. Both factors contribute to lower work efficiency. This is a very important issue from our scalability perspective. The co-ordination mechanism supporting the transfer of products between the product packaging and the order packaging is the map in the work order depicting the interim storage and the product's location within it. This co-ordination mechanism is not working well even today. When the workload increases the transfer between the processes will most likely break down.

In addition to the two product families that are interim stored, there are a number of standard products stored in another storage area called the Backflush storage. The products in Backflush storage are not stored according to any system at all. When they arrive they are simply placed in a convenient empty space. In order to find the items to be packaged the order packager either has to remember where the products are or has to confer with a colleague. Usually there is someone around who knows where they are. If this is not the case the packager has to search the Backflush storage in order to find them, and since it is rather large it may take quite a while. Spending fifteen minutes searching for a specific product is not unheard of. The Backflush storage is an issue that must be addressed. This is not functioning efficiently today, and it will become even more difficult to find packagers that have knowledge about where products are stored when the scale of operation increases. This means that it will take even longer to find the right products unless the situation is remedied. IT-support is needed to co-ordinate storage and retrieval from the storage.

Some packagers use the handheld computer to count standard products to be sure they get the number right. If the packager tries to scan too many products the handheld computer sounds a warning.

Sometime during the process the order packager also has to mark the cables (if included in the order) with the appropriate parcel number. To do this he has to leave the building and walk some hundred meters to a tent, which houses the cable drums. The cable drums are not stored there according to any system what so ever. He has to search through the entire tent in order to locate the drum marked with the correct order number. This can sometimes take up to half an hour according to the workers. Once the correct drums are located, a note with a parcel number is attached to each of them. When the order is to be shipped the forklift driver has to locate the cable drums again causing the whole process to slow down even more.

When a parcel is fully assembled the packager prints out a number of labels at the label printing station. The parcel is labelled with bar codes representing the parcel number and order number and a label with delivery address. Depending on the destination, a label with content information and another label with customer specified markings may be attached to the parcel as well. The order packager then measures the height of the parcel (due to the standard size of a pallet he does not have to measure the width and length of the parcel) and writes down the figure on the parcel. He uses a special pallet truck with built-in scales to weigh the parcel and jots down the figure next to the dimensions. These figures are then copied onto a weight list. If necessary, the packager also uses a special machine to wrap the parcel in order to make it sturdier during transport. He then separates one of the E-orders from the work order, stamps the parcel number on it and puts it in a small plastic bag together with a quality report form, also stamped with the parcel number, and attaches it to the parcel. The remaining E-order is given to an administrator. If it is an international shipment, the administrator faxes information about the consignment to the company shipping agent. If the parcel is to be shipped within the country a consignment note is written using an ordinary typewriter. The note contains the following information: address, order number, number of parcels, volume and weight. The adhesive consignment note is then attached to the parcel. The

parcel is placed directly in the loading bay by the packager himself. If it is an international shipment the forklift will collect it and place it in final storage, where it will remain until the freight company arrives to collect it.

The packager docks his handheld computer and downloads the packaging data into the central computer system. He walks over to the board and marks the packaged order items on the order listings with a magic marker. When all order items of a given order are marked, the packaging process is completed. The packager takes a new order from the board and the process begins again…

5.3 Key Issues

We now summarise the identified key issues that must be addressed in order to achieve a scalable work practice. Our proposed solutions to the issues will then be discussed in the design proposal section below.

The issues are:

- The overview function of the board: An overview of the current workload is important for setting the work pace. Until now the board has been working well, but it can no longer display the large number of orders in a useful and productive manner. Another solution with better capacity is needed due to the high rate of growth. This is a matter of high priority.

- The interim storage area: It is already impossible to store all products in the small interim storage area and due to the growth this problem will become even more severe as time progress. This also applies to the observed difficulties in finding the right products stored in the area. Finding a solution is imperative since the interim storage area is a crucial element in the work practice, not only does it take time to search for products, it also takes up valuable working space needed by the order packagers.

- External site co-ordination: The co-ordination with external sites is barely functional today. The lack of information of the state of an order is affecting the throughput since an order cannot proceed to order packaging unless all items are available. With an increasing scale of operation far too much time will be spent on deciding whether all products have arrived so that the order packaging process can begin.

- The work order: It happens that work orders simply disappear. Sometimes they are packaged into a parcel, sometimes they are dropped under a shelf. As the number of orders, and thereby the number of work orders increase, it is very likely that the numbers of disappearing work orders will increase as well. The current incarnation of the work order is not suitable for large volumes of orders, since papers are difficult to handle in large quantities and are easily lost or misplaced.

- The work activities: Our observations show that the workers are very efficient when performing each work operation. With better co-ordination support, they will be able to cope with the increasing scale of operation.

- Stop orders: If it is discovered that something is wrong with an order that has entered the packaging process, the clerks have to find the individual work order to stop it. This means finding the right worker on the shop floor. It still works since the department is rather small, but when it grows larger it will take longer time to find the person in possession of the work order.

- The Backflush storage area: The storage area is not well functioning today. It is uncoordinated and confusing. Often the workers must find and ask the right person in order to find the sought after item. As the workload increases it will become even more chaotic. This is an urgent matter to attend to.

- The final storage area: This works very well today due to the IT-support. When the scale of operation increases problems will arise due to the limitations built into the current system.
- The cable handling: The handling of cables is not well functioning today. It takes a very long time to find the right cables, and there are two persons that have to find the cables at different times: the order packager and the forklift driver.

6. The Design Proposal

Here we present our design suggestions, beginning with a description of the revised co-ordination mechanisms. Changing the co-ordination mechanisms affects the two main processes, product packaging and order packaging. We discuss the effects of this and present new ways of handling the storage areas.

6.1 Co-ordination Mechanisms: The Board and the Work Order

We suggest that the board is replaced in its entirety by a computer system consisting of one or several large computer screens and a large number of handheld computers connected to a central server via a radio based LAN. The screens will display awareness information, such as the number of order to process during the day, how far along in the process orders are and so forth. Basically it is replacing the listings function of the board and since it displays statistics generated from the central computer system it is possible to display this in new and interesting ways.

The work orders information will be downloaded directly into a more sophisticated version of the workers handheld

computer and is displayed as lists of items to package. This way the paper-based co-ordination would be removed. The T-order will disappear, since the functionality of the T-order is to provide data for the handheld computer used today. This solution does not only eliminate the need for a cumbersome paper based work order, but also the need for scanning every single order item of each order into the handheld computer before the actual packaging work can begin. If a handheld computer with a large graphical display is used, the map previously included in the work order could be shown graphically on the handheld computer. It is also possible to use a system of co-ordinates to store information on where different products are located. Since all the order information is stored on the server there is no need to print the E-order until it should be attached to the parcel at the very end of the packaging process. Using this system all the information, both co-ordinating and awareness generating, can be accessed and displayed electronically eliminating the paper based co-ordinating mechanisms causing problems today.

Since all events are registered and reported electronically to the server, it is also possible for the administrative staff to access the system and see whether the handling of an order has begun and how far along in the packaging processes it has come. If necessary, the staff can send out stop orders directly to the packager via the handheld computer and tell him to stop working on the specific order. It also rids the packager of the paper handling at the end of the process where he checked off the packaged order on the notice board and turned the work order over to an administrator. This is automatically handled by the computer system. The new system eliminates many of the problems arising in the order packaging process today. It not only allows the packagers to work more autonomously but also to be more efficient since much of the searching conducted today is eliminated. The operative information needed to perform the packaging process is immediately available in an updated form.

6.2 Product packaging

The reason for having a separate product packaging process is that some customers want their products configured in a special ways. They may also want different sets of accessories. We have identified no serious problems with the product packaging process per se, but how the process is conducted has a serious impact on the interim storage area, where the processed items are placed until they can be handled by the order packagers. Until now it has been easier to interim store the products according to which order they belong to, as opposed to what product number and index they have. This system worked very well as long as the number of orders was relatively low and the number of different configurations was large. Today the number of orders is ever increasing and storing order specific products gives a much more complex storage system than if only standard products where stored in the interim storage area. The space available in the interim storage is limited and it has currently spread out into adjacent areas, stealing workspace from the order packagers. The location of products not placed on reserved shelves is not covered in the E-order, thus the need for ad hoc markings on the enclosed map. As a consequence, it takes the order packagers a long time to find the products, and since each product is tied to a specific order it is essential to find the exact item, not just one with the right product type and index number. It is vital to find a solution where interim storage of large quantities of order specific products is not needed. Some products must still be manufactured and configured for specific customers, but our ambition is to remove the direct relationship between the product packaging process and work order.

We suggest a change in the product packaging process, which will result in an interim storage with standard products. The products will not be stored as per order, but rather as per product type and index number. When the order packager needs a product he only has to locate the right product type, not a specific item. According to the product packagers non-standard orders make up less than 20% of all products passing through

the department. A proportional part of the interim storage area will be dedicated to storing these special items as per order.

The product packagers will get their tasks directly from the computer system, as opposed to the indirect route by work orders taken today. The product packagers' assignments will be based on stock information and on what orders are to be shipped in the near future. This way the interim storage will be both simply ordered and kept as small as possible, yet always have just enough products in stock for the order packaging department. The new design does not affect the current work activities as to how products are packaged but only as to what products are packaged. This way as much as possible of the product packaging competence is preserved.

The design suggestions allow the product packaging process and the order packaging process to become more loosely coupled, thus decreasing the need for co-ordination. They do however place great demands on the information systems supplying the product packaging process with tasks to perform.

6.3 Order packaging

The new order packaging process we are proposing begin when a packager turns on his handheld computer connected to the department's server by a wireless LAN. He enters a request for a new order and receives one automatically. From now on he is the person responsible for this specific order. He immediately gains an overview of the order size and composition. He is also notified as to whom the customer is.

At a push of a button the order is displayed as a list of items to package. The handheld computer can sort the list depending on different criteria of the order items, perhaps he wants them ordered by product number or by what storage area he is to collect them from. Each order item has up to date location information supplied by the server over the wireless LAN. As the listed products are picked up they are scanned using the scanner on the handheld computer. The packager can

choose whether he wants to collect all the order items first and then assemble the parcels or if he prefers to collect the items as per parcel. The handheld computer must therefore be able to handle other functions while the task of collecting order items is still unfinished. It shall however clearly tell the packager that the entire order is not yet finished so that the packager does not risk missing items.

We also suggest that label printing can be initiated from the handheld computer. The software controlling the label writer must be connected to the other systems. That way the packager can be notified as to special cases, such as a certain customer wants a label of contents on a particular parcel. When the packager wraps the parcel, he should be able to estimate the height of the parcel from markings on the wrapping machine. Both height and weight is noted in the digitised version of the weight list using the handheld computer. Once a parcel is fully assembled the packager makes a note of this on his handheld computer. A message is immediately sent to the forklift driver who collects the parcel and places it in a suitable position in the final storage area.

The design suggestion lead to reductions in the amount of co-ordination work the individual order packager has to perform, allowing him to concentrate on the work activities. With better co-ordination mechanisms and higher quality operative information he can accomplish his productive tasks much easier and more efficiently as well.

6.4 Storage Areas

Only the final storage area works satisfactorily today, much due to the truck computer system. We propose a more extensive computer system, which is integrated into the overall information system by a wireless LAN. There are two reasons for this. First, the current fork lift computer has all storage information on its hard drive and this data is not available unless you interact directly with this isolated computer. Should

the department purchase a second forklift this system breaks down since there is no way to keep the storage information consistent. With the connection to the department server this information can be stored in a common database and accessed and maintained from any number of computers. Second, the forklift computer will also be able to send and receive messages, just like the handheld computers.

There are three other storage areas, which are not working well. These are the Backflush storage area, the storage area for product family C and the cable storage. They all suffer from lack of structure and are all entirely without computer support. This we intend to amend by using the system from the final storage area here as well. Thus we make all the storage areas in the department accessible for stationary computers as well as handheld computers. By increasing the quality and availability of the storage information we reduce the time spent searching for products.

7. Discussion

In this section we reflect on our findings, starting off with reporting on what happened after the study was finished. We then discuss the chosen theory, and argue that it facilitated analysis and design in this case.

7.1 Implementation

Important measures of the validity of the design proposal are how well it is received, to what extent our suggestions are implemented and how well those changes work. During a workshop, which we held after the design proposal was finished, many issues concerning the implementation of our proposal were discussed. These issues where mainly on a practical level, for instance security issues. The suggested changes were

appreciated and the company representatives claimed that they would work on solving the practical problems in order to implement the suggestions. Consequently, the design proposal was well received.

Eight months later we contacted the company to find out what changes have been made. The packaging department has grown, and now has 40 employees, as opposed to 25 when we conducted the study. As predicted the throughput has almost doubled, i.e., they are packaging twice as many units each day. Our interviewee claimed that many of our design suggestion have been implemented in small steps due to economic and organisational constraints. In fact, due to the cultivation approach, the different parts of the design proposal are possible to implement at different times. This allows the company to focus their resources on making each redesigned part mature before moving on to the next implementation. Our recommendation to increase and develop the use of mobile IT-support has also been implemented, but in a slightly different fashion. Instead of using PDAs, they use laptop computers attached to carts, supporting both the mobility and carrying capacity of the individual worker. There are far-along plans to introduce a wireless network, which was one of our main points. Initially, there was some resistance to this due to the problems of electrical interference and security. These problems have been solved. The proposed solutions for finding products in the storage areas have been implemented, except for the Backflush storage area where static places for all products are now used. Our suggestion was a dynamic storage system, but otherwise the solutions are similar. The interim storage area is now indexed by product type, in accordance with our suggestion.

Based on this feedback we draw the conclusion that the company believes that the design proposal was valid and improves the department's performance. A major part of the proposal has been validated in the day-to-day operations. The implemented changes, together with a larger work force, allow them to cope with the increased throughput.

7.2 Co-ordination

Using co-ordination theory in a real world case is not a trivial thing. It has been argued that it is difficult to make the distinctions used in co-ordination theory (e.g., Heath and Luff 1992, Rouncefield et al. 1994). It can be cumbersome to understand what objects are within the field-of-work, if tasks and actions are articulation work or co-operative work, to mention but a few problems. These problems become obvious in a situation where work consists mainly of communication, such as in the vision of the Talk Society (Dahlbom 1997). If all you ever do is talk to people in your personal network, at work as well as in private, does this not make such distinctions as co-operative work and articulation work useless?

Be that as it may, we argue that there are still situations and settings where they prove useful. In the case described in this paper it is clear that the use of co-ordination theory is fruitful. Co-ordination theory and in particular the notion of co-ordination mechanisms became valuable tools for understanding as well as design. By using the distinction between co-operative work and articulation work we where able to better understand the complex work practice with its constant need for co-ordinating activities. Consider for instance workers calling out for the forklift driver when they need products from the top shelves of the Backflush storage. They use direct communication to co-ordinate, i.e. articulate, their activities.

But, as mentioned, there are situations where this concept is not clear enough to provide guidance. For instance the workers co-ordinate the entire packaging process using the work order. This is clearly a form of co-ordination, but the manipulated object is not part of the common field of work. It has been introduced for the soul purpose of co-ordinating activities. Is this still articulation work? In this example we where able to apply the notion of co-ordination mechanisms, which facilitated our aim to investigate the interfaces and interrelationships between the activities. Once these were identified and analysed the design for specific issues became

viable. The exact implementation addressing the identified issues maybe discussed, e.g. the company's choice of using laptop computers, instead of handheld PDAs. However, the both designs are fundamentally the same, i.e. they aim to support the required co-ordination of activities with information technology.

Therefore, we believe that co-ordination theory is helpful for both analysis and design in such industrial work settings.

7.3 Cultivation

The idea of using cultivation rather than construction influenced us throughout this project. It has helped us decide on using co-ordination mechanisms as framework for analysis, as well as on how we were to structure the resulting design proposal in order to make the proposed changes possible to implement.

Studying the department from a cultivation perspective, the initial constraints of non-disruptive changes due to the mission critical nature of the work, made us realize that it would be much more costly and disruptive to actively change the work rather than the technology supporting it. In order to change the way of working, the company would have to retrain the personnel as great cost and performance loss. Information technology on the other hand is relatively cheap and can be introduced gradually to make the disruption minimal. Analysing the field data using the co-ordination mechanisms framework we were able to isolate the interfaces between tasks and study how well those interfaces were functioning. This way we can introduce new IT, performing the co-ordination mechanism functions without greatly affecting the work activities it co-ordinates. The workers would then adapt (evolve) their own work practice using the new IT support.

This contrasts quite sharply to the findings presented in Hanseth (1996) where it is suggested that it is the information infrastructure (i.e. the technology) that must be cultivated. We believe that this is due to the difference in scale between the cases. While we are looking at the organisation of a department,

Hanseth investigates large information infrastructures, such as the Internet. Large infrastructures, Hanseth argues, are not possible to change using a construction approach. They must be cultivated. In our case, on the other hand, it is the way of working that we cultivate, not the infrastructure.

8. Conclusion

Our objectives were to investigate to what extent the use of co-ordination theory, in conjunction with a cultivation approach, supports (1) the understanding of a work setting and (2) the design of work practices capable of coping with a higher scale of operation.

Co-ordination theory provided the conceptual framework for studying and analysing the work setting. It made it possible for us to identify interfaces and mechanisms important for co-ordinating the work activities. The cultivation approach provided a much-needed perspective on how to implement the changes without disrupting the work and what the design must be like to allow the organisation to continue to operate during implementation. This case serves as a good example of how co-ordination theory and a cultivation approach can be applied in an industrial context when scaling up a work setting.

9. Acknowledgements

First of all we would like to thank our supervisor, Fredrik Ljungberg at the Viktoria Institute. Without his help we would never have managed to produce this paper. Furthermore, Magnus Bergquist and Nina Lundberg have been of great help, both during the ethnographic study, and the analysis of thereof. Bo Dahlbom and all our colleagues at the Viktoria Institute have given us helpful comments. We would also like to express our

gratitude towards the company, in particular our two contact persons, who helped us so much during the study. We are grateful to the anonymous reviewers for extensive and useful comments. Finally, we want to thank the Internet Project and SITI for funding our research within the Mobile Informatics research program at the Viktoria Institute.

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Second Paper

Moving Out of the Meeting Room: Exploring support for mobile meetings

Jens Bergqvist, Per Dahlberg, Fredrik Ljungberg and Steinar Kristoffersen

"The structuring properties of the interaction order in real-time settings such as meetings have enormous (and as yet largely ignored) consequences for the overall structuring of organizations. Caught in a meeting and connected through a series of interactions across time and space are the people, ideas, decisions, and outcomes that make the organization."

(Boden 1994, p. 106)

Abstract

Recent research in CSCW shows that people become mobile in order to meet. Such meetings take place everywhere. Therefore, they are difficult to conduct using traditional meeting support. In this paper, we empirically examine mobility in face-to-face meetings. The objective is to characterise such encounters and suggest meeting support beyond the meeting room. We have identified four dimensions of such mobile meetings: establishing meetings, multiple threads, briefings, and technology. The implications

from this study complement existing research with guidelines for mobile meetings.

1. Introduction

Within the field of CSCW considerable attention has been paid to information technology (IT) support for meetings. One strand of this research has focused on meetings between co-located people. Research efforts in this category involves technological contributions, e.g., the design of meeting rooms (Nunamaker et al. 1991), roomware (Streitz et al. 1997), advanced meeting technologies (Elrod et al. 1992), and software applications (Pedersen et al. 1993), but also empirical contributions, e.g., studies of the ways in which people make meetings happen (Mantei 1989; Moran et al. 1996). Clearly, these contributions have been very important to the field.

One issue that has not been so much addressed in the research on meeting support is mobility. In fact, mobility has until recently been largely overlooked in the CSCW literature (Luff and Heath 1998). Some recent empirical accounts on the topic have shown that people are often mobile to meet each other and solve problems (Bellotti and Bly 1996; Kristoffersen and Rodden 1996). Such meetings can occur in many different places, which makes them difficult to assist by means of traditional meeting support (e.g., electronic whiteboards), which tend to be static and tied to dedicated places. By meeting support we understand any IT designed to assist collaboration between people who have “come together” to deal with work-related issues (see, Nunamaker et al. 1992). Related to but yet different is support for informal communication, which seeks to assist unarranged, unscheduled, and less goal-oriented engagements with random participants (Fish et al. 1990; Kraut et al. 1990). The empirical research on informal communication has involved studies of interaction between co-located people

(Whittaker et al. 1994), however the technological contributions have exclusively supported remote interaction (Fish et al. 1993).

The objective of our research is to explore meeting support beyond the context of the meeting room, i.e., assist people who come together in face-to-face meetings in other places. The purpose of the study reported in this paper is to begin to investigate work in real settings in a systematic way, with a particular objective to inform the design of such meeting support. The study explores the work of staff at the central IT department of the city of Gothenburg, Sweden. By reporting the fieldwork and elicit implications for the design of support for mobile meetings, we seek to add to and extend the emerging CSCW literature that investigates mobility for the purpose of design.

We start the paper by summarising the research on meeting support and mobility (Section 2), and describe the research context of the study (Section 3). In section 4, we report the results of the empirical study, and in section 5 we discuss the findings in relation to existing research, and the implications the results may have for design. In section 6, we conclude the paper.

2. Related work

There are two areas of related work to the research presented in this paper. These are the CSCW research on meeting support and mobility.

One strand of research on meeting support for co-located people has focused on equipping meeting rooms with IT support (Nunamaker et al. 1991). These rooms often involve expensive and special-purpose hardware, which makes them static and tied to dedicated places. Related to this research is what recently has been called roomware, i.e., the combination of information devices and physical objects in a room, e.g., walls, chairs and tables (Streitz et al. 1997). The research on roomware tends to go

beyond the context of the meeting. Research on meeting support also explores advanced hardware technologies, e.g., electronic whiteboards (Elrod et al. 1992), and software applications with which these could be equipped, e.g., the Tivoli application (e.g., Pedersen et al. 1993). Software for meeting support running on light weight technologies like PDAs (Personal Digital Assistant) has been explored as well (Myers et al. 1998). Research also investigates the integration of meetings along the dimensions of time and space (Inoue et al. 1997), as well the integration of meetings and other group activities (Mark et al. 1995). Another strand of research conducts empirical studies of meetings. The studies evaluate meeting support and inform design (e.g., Mantei 1989; Olson et al. 1992).

Most research on mobility can be characterised as empirical studies (but see Kristoffersen and Ljungberg (1998) for an exception). Most of these concern mobility as a consequence of an interest in another topic, e.g., informal workplace communication (Whittaker et al. 1994), the effects of video technology in banking (Kristoffersen and Rodden 1996), co-operation and IT use in a dispersed design team (Bellotti and Bly 1996), and the practice of photocopier technicians (Orr 1991). As far as we are aware, Luff and Heath (Luff and Heath 1998) is the only contribution in CSCW that explicitly investigates mobility for the purpose of design. Luff and Heath reconsider three empirical studies from the point of view of mobility. The focus is not personal mobility only, but also the mobility of artefacts, called micro mobility. The analysis involves three cases with three different focuses on mobility. These are micro mobility in medical consultation, remote mobility at a construction site, and remote and local mobility in the London Underground.

In this paper, we seek to bring together meeting support and mobility, and in doing so, address an issue that has not been previously explored: meeting support for mobile settings.

3. Research site and method

The research was conducted at an IT company owned by the local government of Gothenburg, Sweden. The company has a wide range of responsibilities. The most important are: consultation, design, installation and support of software, installation and support of hardware, and maintenance of the local government's servers. The clients are distributed all over the city. The company employs 300 personnel, and the annual turnover is approximately 280 million SEK (approximately $30 million).

The department we investigated has about 25 employees. The main task is to design, install, and support Lotus Notes applications and databases. Many employees both work as project leaders and developers. The manager of the department (Bonnie) has her own office. Everybody else either shares office or works in the office landscape.

We spent approximately 70 man-hours doing close participant observations (or, shadowing), i.e., following every single move of a particular person. Everybody was aware of the research and its purpose, and field notes were taken continually. The analysis of the empirical data aims to "make sense of massive amounts of data, reduce the volume of information, identify significant patterns, and construct a framework for communicating the essence of what the data reveal" (Patton 1990, p. 371-372). Having transcribed the field notes, we started the coding of the empirical data. This meant going through the data carefully, making notes and labelling data that seemed to capture underlying patterns. In the analysis, we used pseudo HTML to tag the field data, e.g., meetings in the office, and Perl scripts for processing it, e.g., meetings in the office following a formal meeting. Gradually, the coding process became a matter of interpretation, i.e., "attach significance to what was found..." (Patton 1990, p. 423).

4. Results

In this section, we summarise the results of the empirical study. The analysis is based on the 88 face-to-face meetings we observed. These meetings took place away from the desktop for at least one of the participants (thus, they were considered mobile), and they were clearly related to work. We excluded traditional meetings, e.g., the weekly group meeting.

In table 1, we summarise the meetings observed according to where they took place (away, home and elsewhere) and whether or not IT was involved (IT involved and no IT involved). Home means that the meeting took place in the office of the person shadowed, i.e., someone else (one or more) had been mobile to establish the meeting. Away means that the meeting took place in the office of someone else, i.e., (at least) the person shadowed had been mobile to establish the meeting. Elsewhere means that the meeting did not take place in an office but somewhere else, i.e., all people involved had been mobile to establish the meeting.

As we can see in the table, the number of meetings were quite equally divided between the three categories (28, 24 and 36). Of the 88 meetings, 52 took place in offices, and 36 elsewhere. We can also observe that most of the meetings did not involve IT (74 of 88).

Place	IT involved	No IT involved	Total	%
Away	4	24	28	32%
Home	3	21	24	27%
Elsewhere	7	29	36	41%
	14	74	88	100%

Table 1. Summary of the meetings observed.

The purpose of the analysis is to serve as a source from which we can elicit implications for the design of meeting support for mobile workers who engage in face-to-face meetings. We identify four important aspects of the ways in which such meetings take place. These are:

- establishing meetings,
- multiple threads,
- briefings, and
- technology.

4.1 Establishing meetings

The focus of the analysis is meetings in mobile settings, i.e., meetings that take place away from the desktop of at least one participant. This means that all meetings we report here were preceded by at least one person being mobile. In most cases (52 of 88), the person who wanted to establish the meeting simply walks to the office of the person with whom she wants to interact. When arriving there, one of the persons would typically indicate the presence of herself or the other party (one or several). For example, the arriving person could ask "Do you have a minute?" or "Have you read the email I sent you this morning?".

However, this does not always happen. For example, consider the excerpt below. Previous to this situation, Ursula and Bonnie have been discussing a contract.

> [Bonnie is engaged in a meeting with Henry in her office.] Ursula enters the office. She says nothing but leaves a document on top of Bonnie's keyboard. Bonnie and Henry continue to talk as if nothing had happened. [...] Henry leaves. Ursula returns and points at the document she left earlier...

What seems to happen in this situation is that neither Henry, Bonnie nor Ursula think it would be appropriate to interrupt the ongoing meeting. Bonnie and Henry just continue their conversation, and in doing so, they indicate to each other, and Ursula that it makes sense to continue the meeting. Because

Ursula says nothing, but leaves immediately after having placed the document on the keyboard, she seems to agree. Accordingly, for all three people involved, it seems to make sense not to establish a new conversation when Ursula shows up, and therefore a new meeting does not happen. We made several similar observations during the study.

Of the 88 meetings, 36 took place elsewhere, i.e., in another place than the office of a person involved. One reason why is that the person who wants to establish the meeting encounters the person(s) with whom she wants to interact on the way to her office. For example:

> [Bonnie and Ursula have previous today been discussing a contract] Bonnie reads the contract. After a while, she walks towards the door of the office "to check something with Ursula." But Ursula is just passing by in the hallway. […] A new discussion follows.

In other cases, the person who wants to establish the meeting does not find the person with whom she wants to interact with (typically: she is out of the office). She continues to seek for her and finds her somewhere else. For example:

> Arriving at his desktop after the lunch break, Errol finds a PostIt note on his desktop written by Amanda. Amanda writes that she wants to talk to him. Errol walks away towards Amanda's office, but she's not there. Errol finds her in the printer room from which they head towards Amanda's office.

Quite frequently, meeting participants want to invite more people in to the discussion. To do so, they could go to the person (one or several) in question, asking her to join the meeting. For example:

> Annie and Errol are discussing the X SOFTWARE application when they realise that they need to invite Ursula into the discussion. Therefore, they simply walk away towards Ursula's office. …

Sometimes this kind of mobility does not aim at a particular person, but a role. For example:

> Errol and Annie are engaged in a meeting. They discuss the software licenses of X SOFTWARE [a Lotus Notes based system]. Errol says: "It's funny that X SOFTWARE is include in the Y SOFTWARE package, yet it seems to require new licenses." In order to find out they need to talk to "somebody who knows." However, "since the boss is gone, it may be the best thing to do to talk to Ursula." They decide to go see her.

In this situation, Errol and Annie seem to want to talk to anybody who can help them solve the problem ("somebody who knows"). It seems as if they would have asked the boss if she had been there. However, since she is not available at the moment, they decide to see someone else who could help (i.e., Ursula).

4.2 Multiple threads

The meetings typically involve discussions on many different topics. Topics are introduced, suspended, replaced and resumed, and while some are picked up in several meetings others just seem to fade away. Such micro discussions and the ways in which they occur, have been called threads. Because meetings tend to involve many threads, which are not introduced, dealt with and completed in a sequential manner, we will describe the structure of the meetings in terms of multiple threads.

Threads that have been dealt with in previous meetings are sometimes just picked up in later meetings. This would typically happen in meetings with the manager. New threads in a meeting seem to be picked up in many different ways. For example, one person could associate a topic with something that another person said, e.g., "By the way, I also …". However, threads do no just pop up, but are introduced and resumed in an intelligible way. In some cases, the topic would be obvious, e.g., someone reporting that she has done what was agreed on in a previous meeting, while in other cases it would have to be

explained, e.g., when someone in a discussion says "This reminds me of…" and introduce a new thread. If someone picks up a thread that does not make sense, then the other people would typically make this obvious. They would do so by hinting that an explanation is expected.

To illustrate the structure of threads during and between meetings, let us briefly describe a typical situation for Bonnie (the manager).

> [Bonnie is in her office]. Ursula enters the office with a contract. Ursula wants Bonnie to go over it before filing it in the Lotus Notes system. […] Ursula leaves the room […]
>
> [Bonnie and Ursula have previous today been discussing a contract] Bonnie reads the contract. After a while, she walks towards the door of the office "to check something with Ursula." But Ursula is just passing by in the hallway. […] A new discussion follows.
>
> Henry enters the office and explains that he cannot attend a meeting: "Can anyone else attend?" Bonnie calls Ian [on the phone] to check what the meeting is about… Henry leaves the office during the call. […]
>
> During the conversation [the call] Ursula paces back and forth across the room. She leaves after a minute or two. […] Bonnie returns to reading the contract.
>
> Ursula returns. Bonnie briefs her about the telephone conversation. They start a long discussion on the issue of software ownership. […]
>
> Larry arrives. He picks up the discussion about laptop computers [..]
>
> Henry enters. He wants to discuss a pricing issue […]
>
> Ursula enters the office. She says nothing but leaves a document on top of Bonnie's keyboard. Bonnie and Henry

> continue to talk as if nothing had happened. […] …Henry leaves.
>
> Ursula returns and points to the document she left earlier. […]

As we can see, the meetings in Bonnie's office involve several threads. When Ursula first enters the office, she introduces a new thread, the contract. The contract is temporarily suspended when the meeting is over and Ursula leaves the room. Later, Bonnie resumes the contract when inviting Ursula into the office. Then the contract is suspended again. However, it is picked up again when Henry leaves the office and Ursula returns. It is interesting to notice that the contract lasts for several meetings (with several other threads).

4.3 Briefings

Much time during the meetings is spent describing things to each other. Some of these briefings concern what people have done in the past, while others concern what they plan to do in the future.

Briefings about the future could be information about, for instance, a future project or a customer visit. One example is when Amanda informs Errol about the new file structure for the web site.

> Amanda [a Lotus Notes administrator] enters Errol's office. She describes to Errol that the file structure of the web server is messy. One reason, she explains, is that "it was not designed for so many documents." […] She continues: "It was designed by company X and Paul." Amanda explains that a new server is going to be purchased, and that Chrystal has designed a new structure."

In this situation, Amanda briefs Errol about things that do not concern him primarily, but which are good-to-know. It is

interesting to notice that the briefing involves past events as well as future plans.

Briefings about the past can be follow ups on tasks that have been discussed previously. We also observed the ways in which people brief each other for the purpose of making sense of past events. Previous to the excerpt below, the servers at the company had crashed. This was noticed by the employees.

> The systems administrator shows up in the corridor. He is in a hurry. When passing by the door to Bonnie's office, he exclaims "Somebody has dropped a plate on a fuse! The server of our company and the tramway had a power failure!"

Here, the systems administrator explains to Bonnie why the servers are down, thus he gives reasons for why the servers had dived.

Briefings could also be people describing what they plan to do. Consider the following example:

> Ursula enters Bonnie's office. She brings with her a contract. She says she wants Bonnie to go over it before filing it in the Lotus Notes system. Ursula explains to Bonnie that "the contract partner will probably visit them this evening." […] Bonnie explains that she "can't access some objects in the project data base from home." She also says that she's "going to convert the document verbal description of the business plan to a word processing file." In addition, she describes that she "plans to work at home tonight," and that she will contact Ursula if she makes any updates.

In this situation, we can observe at least two briefings which seem to play major roles in the interaction. First, Ursula describes to Bonnie that the contract partner will make a visit later. Second, Bonnie says she plans to work at home tonight, but that she will contact Ursula if she makes any updates.

There are also briefings that appear serve the purpose of giving order. For example, consider the following excerpt.

> Ursula's cellular phone rings. In the subsequent conversation, she makes an offer [it's a client]: "we can do

> this… we can do that." She informs the caller about costs and what is included: "education and support." She also says that "Annie will be responsible." When the phone call is finished, Ursula walks to Annie's office. She tells Annie about the call, and the task. She also describes that it could be good to make some cost calculations. Ursula leaves.

Here, Ursula in a descriptive manner explains to Annie what has been said during a phone call with a client. She also describes a task and what ought to be done. Clearly, she does not simply describe the call and the task to Annie, but requests her to assume the responsibility. Since Annie does not express another stand point, she seems to accept the request. We made other similar observations about people briefing each others about what ought to be done in the future.

4.4 Technology

Of the 88 meetings observed 14 involves the use of IT. On these occasions, IT either serves as a resource for face-to-face interaction, or as a means for interaction with remote people.

When people enrol IT (e.g., a PC) in a face-to-face meeting, they typically re-arrange the way in which the interaction takes place. In a sense, what often happens is the opposite to the micro-mobility observed in the studies by Luff and Heath (Luff and Heath 1998, p. 306), i.e., "the way in which an artefact can be mobilised and manipulated for various purposes around a relatively circumscribed, or at hand, domain." According to our observations, it is not the artefacts (IT) that are "mobilised and manipulated," but rather the participants of the meetings (Luff and Heath made similar observations). What typically happens is that people want to check something on the computer network. Therefore, they move to a PC at hand which one of them starts to operate. The other participants would stand behind the operator, glancing over her shoulder.

The way in which the meeting takes place when the PC is enrolled differs significantly from the way it took place previously. When the PC is used, only one person can be in control, if many people are involved it can be difficult for everybody to see what happens on the screen, eye-contact is lost when everybody looks in the same direction, and so on. However, these were the premises on which the PC could be involved in the face-to-face interaction. It is striking how this differs from Luff and Heath's (Luff and Heath 1998) description of the ways in which medical records were used in medical consultations.

We also made observations of how IT was used in meetings for interaction with remote people. The IT that people use in these situations is the cellular phone. What typically would happen when someone in a meeting starts to use a cellular phone, is that the meeting is suspended (compare: threads). Everybody but the person using the phone is quiet. It seems as if they just listen and wait for the call to end.

Making a phone call would typically be a consequence of an emerging need for external contact defined by the meeting participants, e.g., that something needs to be sorted out and a phone call is made accordingly: "Let's call her and find out." Consider the following excerpt from a meeting.

> Errol explains that it's not obvious who is going to join the project. "Susan and myself know something about the technological issues," he explains. But they would also like to see some more people involved. [...] Susan picks up the phone to give Bonnie (the manager) a ring "to find out."

As mentioned previously, instead of making a phone call, the entire meeting sometimes moves to persons who needs to be enrolled into the conversation.

Upon finishing the phone call, the caller would typically explain to the other meeting participants what the other party said (in a sense, recapitulate the conversation).

We also observed meetings where a participant received a call. What typically happens then is that the receiver explains to the other meeting participants who was calling, e.g., by saying

"Hi Mr X!", but also for the caller that she was in a meeting, e.g., "I'm in a meeting…". For example:

> Steve's cellular phone rings. He answers. "Hi there… I'm in a meeting with Bonnie." […] Upon finishing the call, he explains: "It was Amanda."

5. Discussion

The meetings we investigated seem to share features with informal communication and meetings, as described in the CSCW literature. However, as we shall see in the discussion below, there are also important differences. To emphasise these, and highlight in what ways our observations can be distinguished from previous contributions in the field, we introduce the concept of mobile meeting.

5.1 Mobile meetings

Interaction takes place in meetings, but meetings are not simply interaction. Meetings are deliberate efforts to establish organisational order and bring about work. Meetings bracket out people, places, and agendas in such a way that it becomes clear who are the appropriate participants, which topics may be raised, etc. One objective of this paper is to bring the social accomplishments of this bracketing to the fore, and sensitise designers to the practical requirements of attending such meetings. Within a CSCW context, the purpose thereby is to improve technological support for achieving mobile meetings.

A meeting may comprise of formal or informal arrangements for turn-taking, participation and sticking to the agenda. The typical meeting (see, Jay 1993) takes place in a meeting room. It fulfils a specific function, it is scheduled and organised according to an agenda, it is usually attended to by an

invited group of people, and it often takes place regularly. Formal meetings are usually understood as officially convened, with fixed membership and agendas. They often occur regularly and have a directed and restricted set of turn-taking mechanisms, which are managed by a chairperson. Informal meetings, on the other hand, are generally task or decision-oriented. They are clearly distinguished from informal communication, as understood by Kraut et al. (Kraut et al. 1990), by being convened, albeit often verbally. Informal communication is often positioned as the opposite to meetings. Informal communication is usually not planned or used to articulate formal functions. It can take place anywhere and involve random participants. It may be seen a social event rather than a meeting, nevertheless, it may of course relate to work in other ways.

The issue of participation is crucial. An organisationally defined group attends to a typical meeting. Attendees to mobile meetings were, on the other hand, all closely engaged in the activities of concern to the meeting (compare: establishing meetings). Moreover, we observed that people even left mobile meetings when they did not concern them any longer, which may be considered inappropriate behaviour in typical meetings. Informal communication, on the other hand, has an open set of participants.

Informal meetings are generally unrecorded, or even explicitly off-the-record (Boden 1994). This is in contrast to mobile meetings, which are often concerned with allocating responsibilities and action points which are recorded, or need to be recounted for an external purpose later (compare: briefings).

Informal meetings, albeit not having a designated chair, usually have a de facto responsibility assigned to the most senior person (Boden 1994). The activity of chairing, moreover, is often territorial, inasmuch as the meeting often takes place in the office of the person who takes on the role as chair. According to our observations, mobile meetings often (in our case: 73%) take place away from the office of the initiator, and they tend to be less territorial. In contrast to typical meetings, which are tied to

a few dedicated places, mobile meetings and informal communication could take place in almost any places.

We claim that mobile meetings may be informal as well as formal and that they are, indeed, proper meetings, with a expected and accountable set of participants and agenda that needs to be followed clearly, from our excerpts, alien issues are often simply ignored.

5.2 Establishing mobile meetings

Mobile meetings are established through deliberate efforts involving physically seeking out and negotiating with potential participants, bracketing the subsequent communication and agreeing on topics

Some meeting support systems treat the convening and establishing of meetings as detached from the meetings themselves. They usually support requests for participation, and may distribute documents. Some systems also maintain the shared calendars of participants (Ephrati et al. 1994). These designs, therefore, assume that people will be at their workstations well before the meetings, with time set aside to prepare and articulate competing organisational chores.

The main implication of our fieldwork is to support locating people, physically as well as virtually, in a highly mobile environment. Supporting negotiation of meetings is a tempting enterprise, but one that we believe may be too obstinate given the formalising nature of technology (see, Kristoffersen and Ljungberg 1999). Leaving the entire process of establishing meetings (locating and establishing) to social protocols, on the other hand, may be too defensive.

Hence, a promising principle for establishing mobile meetings could be affording awareness of the activities (Dourish and Bly 1992) and position of potential participants. Maintaining and managing this type of state information should be a low-overhead activity (Grudin 1994). For the mobile user, calm information appliances (Norman 1998), may support this

functionality. Position may be either absolute or relative to other users. Absolute position shows, for instance, at which office a person is located. ParcTab is one system that provides this kind of support (Want et al. 1995). However, we find that the relative positioning is equally exciting. Relative positioning is based on proximity, one example of which is the Hummingbird system (Holmquist et al. 1998). Hummingbirds give notice when users are nearby.

Establishing meetings is cumbersome (Ephrati et al. 1994). Even with simple technologies, such as the telephone, as many as 60% of all calls fail to connect with their intended recipient (Rice and Shook 1990; Whittaker et al. 1994). We think that one important lesson to be learned for CSCW is that this is part-and-parcel of organisational life. One novel implication of this paper is that members of organisations conspicuously use mobile meetings as a feature to resolve this problem. Perhaps this is one good explanation of why we found no mobile meetings that were pre-arranged using IT (in contrast to (Fish et al. 1993)).

Boden (Boden 1994) claims that meetings cannot start without having a critical mass of members in attendance. We argue that mobile meetings are one way of reaching critical mass, since they take place with fewer participants, topics are dynamically adjusted to the availability of participants, and it may be suspended and resumed when appropriate. The threshold is lower indeed, since one person with a mission seems to be able to pull off a mobile meeting almost regardless.

5.3 Multiple threads

Mobile meetings involve multiple topics. Threads relate to topics, and may be seen as their enactment. Mobile meetings have many topics, but usually only one active thread at any time. Threads are not always completed within a meeting, and the pertaining contributions do not always occur sequentially.

Threads are, moreover, sometimes moved between meetings, thus, they tend to be suspended and resumed.

McDaniel et al. (McDaniel et al. 1996, p. 41) define a thread as "…a stream of conversation in which successive contributions continue a topic, following an initial contribution which introduces a new topic." Whittaker et al. (Whittaker et al. 1994) on the other hand, reported that informal communication tend to be one long session, that is suspended and resumed over time. We found that threads in mobile meetings do not consist of sequential (uninterrupted) contributions, they are not always introduced explicitly, and they can be involved in several meetings.

Considering threads instead of topics as the atomic unit of meetings opens up a new design space, inasmuch as they lend themselves more easily to representations comprising, for instance, participants, documents and place. Thus, a system could conceivably always show the closest thread on top of the mobile user's display. Threads are, in contradistinction to topics, bracketed in actual time and space. In the meetings, threads were shifted frequently and effortlessly. New IT should not make switching more difficult.

5.4 Briefings

Mobile meetings serve as important ways for people to brief each other about past and future events. Because the attendees typically are closely engaged in the activities of concern, briefings are likely to be important for everybody involved.

The PC could be a useful tool for briefings. For example, a project member could perhaps more effectively brief someone else when accessing to the common information space of the project. However, not even a laptop PC seems light weight enough for mobile meetings. Therefore, we suggest the use of calm, ubiquitous devices equipped with features for replication and browsing.

5.5 Technology

Technology in mobile meetings either serves as a resource for face-to-face interaction, or as a means to carry out interaction with remote people. Technology is only used when absolutely needed, and it often makes people rearrange the ways in which they interact, e.g., by trying to use individual IT like the PC as if it was a group technology. When people use the cellular phone in meetings, they typically explain the use context; that they are in a meeting, who the other party is, etc.

Luff and Heath (Luff and Heath 1998) coined micro mobility to describe the ways in which technology (objects-in-interaction) should serve as a flexible resource in interaction. They also reported how people rearrange interaction to cope with technology that does not have this property. Overall, our findings of technology in co-present interaction echo those of Luff and Heath. However, one novel observation seems to be the ways in which people explain context who is calling, where they are, etc. when using technology for remote interaction (cellular phone) within the context of mobile meetings.

Clearly, if technology is to serve as a flexible and augmenting resource in mobile meetings, people need to be able to "mobilise and manipulate" it according the emergent needs of the group. One approach would be to make technology group aware, i.e., make it possible to accommodate it to group use. However, this way of integrating functionality into artefacts may make them capable of doing many things, but non of them particularly well (Norman 1998). Another approach would be to design dedicated information appliances for groups (Norman 1998). It is interesting to notice that this suggestion is quite the opposite of what often is argued in the meeting support literature, namely that group support needs to be accompanied with support for the individual (e.g., to protect privacy).

5.6 Design in progress

Based on the empirical study, and the implications derived from the results, we are currently developing a series of applications for mobile meetings. The applications are programmed in C and run on the Palm III platform. The Palm III is the most widely used portable device. In a sense, it could also be described as micro mobile. Let us briefly introduce two applications that are being developed.

The Dynamic to do list runs on a Palm III equipped with a radio transceiver (originally developed for the IPAD project at the Viktoria Institute, see (Holmquist et al. 1998)). The device scans the environment and give priority to the items of the user's to do list based on the proximity of others. This may support the establishing of mobile meetings, and briefings. We plan to experiment with the same technique on threads.

Figure 1. The dynamic to do list runs on a Palm III equipped with a radio transceiver.

The portable project database replicates selected items from a Lotus Notes project database. The idea is to provide users with easy access to information that is potentially relevant in a mobile situation, e.g., to brief someone about the progress of a project.

We plan to evaluate the applications in the organisation investigated in the study.

6. Conclusions

In this paper we have introduced the concept of mobile meeting. We have argued that mobile meetings are different from meetings already discussed in the literature and supported by CSCW systems, among others, by having: a managed set of records and responsibilities, a dynamic agenda which is closely aligned with current topics, and an open yet not arbitrary set of participants. In contrast to informal communication, on the other hand, mobile meetings are clearly bracketed from other organisational activities.

We have introduced four important dimensions of mobile meetings, each of which has design implications for CSCW.

- First, mobile meetings are established through deliberate efforts involving physically seeking out and negotiating with potential participants. CSCW design should take locating participants into account, but perhaps not attempt to support negotiation.

- Second, mobile meetings involve multiple topics, which are enacted by threads. Threads lend themselves more easily (than topics) to representations comprising participants, documents and place. However, it is important that new IT does not make switching between threads more difficult.

- Third, mobile meetings serve as important ways for people to brief each other about past and future events. Support for briefing could be calm and ubiquitous devices equipped with features for replication and browsing of information spaces.

- Fourth, technology in mobile meetings either serves as a resource for face-to-face interaction, or as a means to carry out interaction with remote people. Technology support is currently limited, and should to a larger extent support situated sharing and micro-mobility.

We are currently designing models and prototyping meeting support based on these recommendations. We believe that mobile meetings represent an emerging organisational feature of which the series of interactions across time and space are the people, ideas, decisions, and outcomes really make organisations.

7. Acknowledgement

This research is a part of the Mobile Informatics programme, which is funded by the Swedish Information Technology research Institute (SITI).

We would also like to thank our industrial partner Linq Systems AB and the research site company.

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Third Paper

Designing for Local Interaction

Johan Redström, Per Dahlberg, Peter Ljungstrand and Lars Erik Holmquist

Abstract

Much development of information technology has been about reducing the importance of distances and user location. Still, many important activities and events are of local nature, for instance serendipitous face-to-face communication. In order to support such communication, as well as other examples of local interaction, we have developed three prototypes all based on wireless short-range communication. The prototypes are functionally self-contained mobile devices that do not rely on any further infrastructure, making the system inexpensive, flexible and easy for users to manipulate. In these experiments, the limited communication range is not conceived as a problem, but rather as a property that can be explored. We present and discuss the Hummingbirds, Generalised Hummingbirds and the NewsPilot, as well as the implications of this approach for human-computer interaction design.

1. Introduction

Information is generally not propagated very far from its origin. Signs can not be read if they are not within sight, signals can not be heard unless within hearing distance, and so forth. In this way, the limitations of our perceptual systems in combination with certain properties of information propagation in physical space (i.e. different kinds of carrier waves travelling through obstacles like walls, floors and outdoor topology) can be said to act as information filters. In order to take part of different sources of information, we have to move around in the environment and in order to talk to each other we have to be co-located.

These limitations are shortcomings of physical spaces that we have been trying to eliminate by the use of information technology. The telegraph made it possible to send messages over long distances, the telephone enabled persons at different locations to speak with each other, and more recently the computing industry introduced us to global networks that make it possible to instantly communicate and share information with people all over the world. The introduction of mobile devices that are carried by their users at almost all times, e.g., pagers and cellular phones, have decreased the importance of location even further. Still, at times proximity is a rather good measure of relevance. We tend to place important objects near us or near the place we are going to use them. Documents and books lying on someone's desktop are more likely to be related to current work than documents placed in filing cabinets or bookshelves. Considering almost ubiquitous resources (at least in office environments) such as power outlets, water taps or rest rooms, proximity is often the main criteria for relevance. We also move around in our environment in order to get a chance to talk people etc. (Belotti and Bly 1996, Bergqvist et al 1999, Whittaker et al 1994).

The usefulness of location as a constraint for information distribution is perhaps best seen when it is removed: now when we can contact almost anybody any time and instantly access

information everywhere we are beginning to experience information overload (Nelson 1994) and communication overflow (Ljungberg and Sørensen 1998). Given the apparent importance of local interaction, such as face-to-face communication, and local mobility or "roaming" in search for people and resources, rather little has been done to support it (cf. Belotti and Bly 1996, Bergqvist et al 1999, Whittaker et al 1994).

In this paper, we describe our explorations of the usefulness of proximity as a constraint for information distribution, starting with development of support for awareness of co-located people. We will begin with presenting related work and then report from three projects all aimed towards supporting local interaction. We conclude with a discussion of our experiences and outline their implications as well as future work.

2. Background

2.1 Local Interaction

Although informal communication per se is not our main interest here, research on this topic presents a number of relevant themes. In occurring definitions of informal communication, it is clear that local interaction plays an important part. For instance Whittaker et al. (1994) uses a wide definition as "taking place synchronously in face-to-face settings"; Fish et al. (1990) mean that while meetings are pre-planned with a predefined agenda, informal communication is a social event, work related or not, that takes place ad hoc when there is an opportunity for communication. The importance of being co-located has been reported in several cases. Relevant studies include Bergqvist et al. (1999) who studied ad hoc mobile meetings in a work place; Covi et al. (1998) who studied the

effects of dedicated project rooms; Fitzpatrick et al. (1998) who discussed the difficulties in designing co-operative buildings with support for awareness and serendipitous interaction for distributed groups and Whittaker et al. who argued that physical proximity is crucial for informal communication (Whittaker et al. 1994).

Extensive research has been done on how to support informal communication using IT. However, in most cases the aim has been to support distributed rather than co-located groups (cf. Dourish and Bly 1992, Fish et al. 1993, Fitzpatrick et al. 1998, Nakanishi et al. 1996). The rationale for this is that many incitements for occasional communication are lost when people are not co-located. Thus, support for awareness about peoples whereabouts that could compensate for not having corridors, lunchrooms etc. as sources of such information have been developed. The notion of proximity has also been used as a metaphor in virtual environments designed for social interaction, for instance in Chat Circles (Viegas and Donath 1999) and FreeWalk (Nakanishi et al. 1996). One of the main differences between these projects and the work presented here is that in a face-to-face setting, the technology does not mediate the communication. Therefore, our focus has.been on how to support communication, for instance by means of providing relevant information.

Another aspect of informal communication is that it is often serendipitous. Hence, technology should support on-the-fly communication, without any need for time-consuming and complex actions on behalf of the user. There are several related attempts to support awareness of colleagues in an office environment (cf. Tollmar et al 1996, Want et al. 1995). These systems differ in that they rely on a fixed infrastructure at a number of specific locations, meaning that they only support spontaneous meetings at certain places. Our aim was to support such communication regardless of any specific locations.

2.2 Ad Hoc Networks and Context-Aware Computing

Ad hoc networks are self-organising wireless networks composed of mobile nodes that do not require a stationary infrastructure. They are designed to be rapidly deployed to provide robust communication in a variety of environments, which often lacks a supporting infrastructure (Haas and Pearlman 1999). Unlike the work presented in this paper, the objective is to allow for communication between all devices, regardless of the present location. Current research on ad hoc networks is highly technical, mostly about network protocols, rather than taking social considerations or novel applications into account.

Besides communicating, the devices have to make use of what information they send and receive in order to support local interaction. The term “context aware computing” was introduced as a part of the ParcTab ubiquitous computing experiment (Want et al. 1995) to describe mobile and wearable systems that collect data from their environment and use it to adapt their behaviour (Abowd et al. 1998, Schilit 1995, Want et al. 1995). A system is said to be context-aware if it keeps track of any aspect of its present context, most commonly location (Abowd et al 1997, Want et al. 1992, Want et al. 1995). Thus, being “context-aware” does not imply that the system in question is aware of all aspects of its context.

The prototypes described in this paper are not aware of their absolute position, but only how they are positioned in relation to other devices. A similar approach has been used in a number of cases, perhaps most notably in the LoveGety (Iwatani 1998), a recent commercial success in Japan. The LoveGety is a small, wirelessly communicating device that detects other LoveGetys within a certain range, in order to support social encounters between people. Other examples of related systems include the Thinking Tags (Borovoy et al. 1996) and GroupWear (Borovoy et al 1998), which tell about relationships between people engaging in face-to-face conversations.

3. Experiments

Beginning to explore the possibilities in designing for local interaction, the field of informal face-to-face communication seemed to be an interesting domain due to its dependence on local interaction and serendipitous communication. We have developed a number of applications all using short-range radio-transceivers (Fig. 1). Below, we will describe the Hummingbirds, the Generalised Hummingbirds and the NewsPilot. The range of the communication varied from about 100 meters in the case of the Hummingbirds, to approximately 10 meters in the NewsPilot, and was deliberately chosen to suit each application.

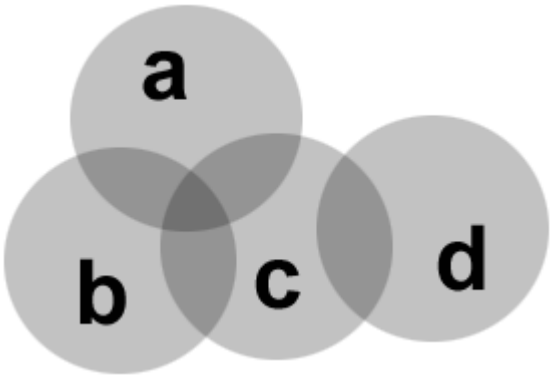

Fig. 1. Figure illustrating four devices, their relative position to each other and what information is available to each of them. The circles represent their respective communication range. In this case, A and B both have access to information distributed by A, B and C; C has access to A, B and D; D has access to C.

3.1 Hummingbirds

The Hummingbird (Holmquist et al. 1999) is a small wearable device equipped with a short-range radio transceiver, through which it broadcasts its identity and receive information about other Hummingbirds in the vicinity. The devices are functionally self-contained, i.e. non-dependent of surrounding infrastructure. The overall objective is to support awareness of “who's around”

within an established group of people. Whenever two or more Hummingbirds are close enough to communicate, the devices give a subtle audio signal and display the identity of the other devices in the proximity. In this way, it is possible for users to know which other Hummingbird users are in the proximity.

Inspired by what is often within "shouting distance", the communication range is set to approximately 100 meters (depending on the number and nature of obstacles like people, walls etc.). The rationale for this range is that as the Hummingbirds do not show in what direction other users are located, the space in which to search for them must not be too large if information about their presence should be useful. The reason for not presenting directional cues on the Hummingbird is partly due to technical difficulties, but more importantly the wish to make the devices as unobtrusive as possible, regarding their use as well as the perception of them. It is important that the Hummingbirds are not perceived as surveillance devices.

In studies of user experiences we have found that the Hummingbird is particularly useful in situations where a group of users are outside their normal environment, e.g., when travelling (Holmquist et al. 1999, Weilenmann and Holmquist 1999). The Hummingbird experiment has shown that for mobile users, it can be valuable just to have the knowledge that other users are in the vicinity, although it is not possible to use the Hummingbirds to mediate communication.

3.2 Generalised Hummingbirds

The results from the experiments with the Hummingbirds inspired a more general platform. The hardware is based on the Nintendo GameBoy, a handheld video game. The GameBoys are fitted with small radio transceivers that are connected to the devices' serial ports (Fig. 2). The range of communication is about 50 meters. The reason for decreasing the range compared to the original Hummingbirds, is the fact that more sources of information would be used and that information therefore had to

be filtered to a greater extent. Modified game cartridges are used for installing custom software.

The Generalised Hummingbird enables users to give their devices arbitrary names, making identification easy. As with the original Hummingbird, Generalised Hummingbirds are only able to communicate by means of sending and receiving their digital signatures (i.e. their “names”). In order to support events over a wider time frame than the present, the names received are displayed as being in one of two states: “active” when the Generalised Hummingbird is currently picking up the signature in question, and “inactive” when the device recently has picked up the signature but ceased to do so (within the last half an hour or so). This enables users to see a trace of what has happened recently.

Fig. 2. Picture showing the Generalised Hummingbirds, i.e., GameBoys fitted with radio transceivers.

3.2.1 Applications

The Generalised Hummingbird enables users to obtain further awareness about activities in their near surroundings using both the "trace" functionality and the possibility to associate devices not only to people, but to places and artefacts as well. For instance, when a user enters a building, an ordinary Hummingbird will pick up what other devices are present, but not which have been there recently. However, if a user places a stationary Generalised Hummingbird at a certain location in the building, its display will show what signatures it has received recently, thus showing a trace of recent activities at that location.

Certain places, like the corridors, act as informal meeting places (cf. Belotti and Bly 1996, Whittaker et al 1994). In order to make information about activities in the lunch room available, users can connect a Generalised Hummingbird to a movement detector, ensuring that whenever there is any activity in that room the device is turned on and, thereby, broadcasting its signature. Correspondingly, the activity of some artefacts might be of interest. For instance, it is possible for users to monitor the availability of fresh coffee using a Generalised Hummingbird connected to a coffee machine, so that whenever fresh coffee is available, a device named "Coffee" becomes active.

This experiment illustrates that it is possible to add a variety of information sources to the network using both mobile and stationary devices, without making the human-computer interaction any more complex than in the original Hummingbird example. Adding new information sources is not any more difficult than moving them into the place in question, and if the devices are to be used for keeping track of some activity, ordinary, affordable and easy-to-manage solutions can be used.

3.3 The NewsPilot

The next step of development is the NewsPilot (Dahlberg et al. 1999), a design based on implications from an empirical study at a Swedish radio station working with broadcast news, conducted by the MobiNews project at the Viktoria Institute. The NewsPilot is based on the 3Com Palm III PDA (Personal Digital Assistant) fitted with a radio transceiver (Fig. 3). The communication range is decreased even further compared to previous experiments, to about 10 meters, since that was a more appropriate range for how far away proximity was relevant at the radio station.

3.3.1 People

The journalists at the station relied on a large number of information resources to select and compile news stories, e.g. local newspapers, television, fellow journalists, .etc. The discussions among the colleagues were an important part of the local news dissemination. Often, several journalists had been involved in various related topics, making for fruitful discussions. To help initiating such discussions each NewsPilot user is able to enter a short message stating what he or she is currently working on. By sending out the message together with name of the user, users can obtain information not only about which colleagues are in the proximity, but also what they are working on.

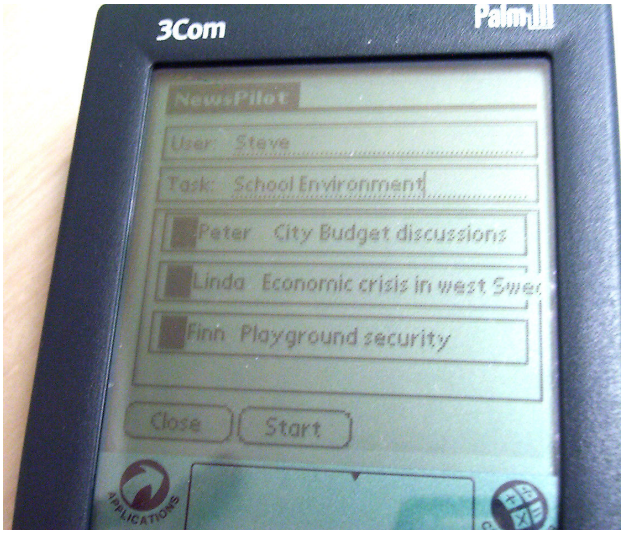

Figure 3. Picture showing the NewsPilot (main screen), i.e., a 3COM Palm III fitted with a radio transceiver similar to the ones used with the Generlised Hummingbirds (Fig. 2).

3.3.2 Places

The second important finding during the study was that it seemed like different types of information were important at different locations. For instance, there was a table and a shelf with newspapers in the centre of the office used for reading and annotating recent newspapers. When a journalist attended this location, he or she was generally interested in getting information about related stories produced both internally and externally. By fitting transceivers to the walls, messages can be distributed to NewsPilots at specific locations. At the newspaper table, the task message from the NewsPilot is received by a wall mounted transceiver connected to a stationary PC, which is used to search local network resources for relevant information. An additional server is used as an interface between the transceivers and network resources. Short messages about findings are sent back to the NewsPilot and presented to the user. Each message contains an abstract and information on where the full story can be retrieved. Although a user hardly wants to walk to a specific location just to filter out information,

if viewed as a complement to traditional searching and browsing, location-based filtering might assist the user in her work.

4. Discussion

4.1 Supporting Serendipitous Communication in Face-to-Face Settings

There seems to be at least two reasons for initiating occasional communication: either (1) that at least one of the participants has a question or subject that she or he wants to discuss, or (2) that the situation as such is an incitement for a conversation. In the first case the subject of the conversation is "known" before the conversation takes place; in the second the subject will be chosen according to the situation more or less spontaneously. While these two cases are superficially similar, the underlying properties differ and will have to be acknowledged in the design of a supporting system.

The first situation is in many respects similar to more "explicit" communication such as phone calls or e-mail, as there are a rather well defined subject and a target person. The main difference is that the property of talking face-to-face is so valuable, that other variables, e.g., when or where to talk, can be left open. A person might choose slightly different strategies in order to catch a talk with her target. Staying in her room will probably mean fewer encounters with other people including the target, than walking around in the office more or less searching for the target. There seems to be a continuous scale of more or less explicit actions in order to make the meeting happen.

The key factor for initiating such a conversation is presumably knowledge that the target person is in the vicinity and available for a chat. This is probably one reason why awareness about other people's whereabouts seems important.

However, if the proposed discussion target is not available for the time being, there is always a risk that the idea sinks into oblivion. We all need a reminder from time to time, and this is one reason why calendars and to-do lists (electronic or paper-based) are so popular. A future implementation of a support for this first kind of situation might therefore be a context sensitive "to-do-list" that reminds its users when the appropriate context for completing the task turns up (cf. Rhodes 1997).

While the first situation bears on one of the participants having an interest in talking about something, the second one seems to arise out of the interest in talking as such. This might be due to being in a place where social interactions commonly take place, or because the situation as such is suited, or demands for that matter, that people initiate conversations. Consider for instance the following common scenario: a person A walks down the corridor and meets another person B. As they begin to talk A notices that B carries a certain book that she is reading too. As a result they begin to discuss the book, and both A and B might get useful information about aspects not thought of, related references etc. Unless B had carried that book, the discussion might never have taken place. This useful sharing of experiences among co-workers obviously does not rely on one of the participants already knowing what to talk about, but on the situation as such in combination with certain resources present. Thus, a support for this kind of situations will not be in the form of a reminder service, but rather some way of presenting relevant information based on criteria such as the participants present tasks, interests, projects etc. Selection of such information could for instance be a matching between current interests of the users in order to find out the least common denominator and present relevant information, functioning in a way similar to carrying around books in the example above. The NewsPilot was an attempt to provide such a tool for journalists at a news agency.

As we have shown, systems based on locally communicating devices can be used in both cases. The Hummingbird supports an awareness of who is in the proximity

assisting a person that has a predetermined wish to communicate. However, it does not provide any help for picking a topic once the parties have met. The Generalised Hummingbird and the NewsPilot provides similar awareness, but with different ranges. Further, the NewsPilot can support persons in choosing a topic to talk about by providing information on what topics other participants are working on. Most of this can be, and have to some extent been, realised using other techniques than local communication between functionally self-contained devices. However, there are some advantages with the strategy employed here that are interesting from a human-computer interaction point of view, some of which will be discussed below.

4.2 Implications for Human-Computer Interaction Design

Let us first sum up a few of the properties of local interaction between devices that we have tried to exploit in order to design easy-to-use technology. The radio transceivers enabled us to use the limited range of communication to create something similar to an adaptive location-based information filter. The communication between the devices was established on the fly, and did not require any explicit actions on behalf of the users. Since the devices are functionally self-contained, users did not have install, configure and maintain any additional infrastructure, except for the stationary information servers used in the NewsPilot, making the systems as a whole easy to manage, move and manipulate.

Our experiences suggest that the principle of proximity as a constraint for information distribution can have a wider applicability than what has been presented here. In the Generalised Hummingbirds, we introduced sources such as places and artefacts, and in the NewsPilot users could have information sent to their PDAs when visiting a certain place. The usefulness of these additions suggests that it is interesting to support local interaction not only among people, but with other “resources” in the vicinity as well. For instance, we can use local

communication between devices in order to let the user combine their respective functionality in the manner Norman suggested "information appliances" to behave (Norman 1998). We can also imagine a scenario where users can create computationally augmented, or rather "amplified" (Falk et al. 1999), environments using "building blocks" that keep their functionality when moved to new locations: if two units work in a certain way together, they will continue to do so when moved somewhere else.

This stands in contrast to most implementations of ubiquitous computing, in which the rather simple devices users interact with, rely on an advanced "hidden" infrastructure. As the behaviour and functionality of their devices will change radically depending on what hidden resources or infrastructures are there to back them up, users will have to care about something that originally was designed to be invisible. This is not very fortunate, considering the aim to hide complexity away from the user. The absence of such hidden resources might help users to build, manipulate and understand their computational environments. Of course, such strictly local networks of devices will not be able to solve all the problems dealt with in ubiquitous computing and intelligent environments, but they might serve as an interesting complement.

4.3 Spaces and Places

When discussing wirelessly communicating devices, the notion of range is often used to describe the size of a cell, i.e. a certain area with a set of devices (people) that all can directly communicate with each other. The term "range" refers to physical distance in space, and it is natural to use this term when discussing spaces. However, the spaces we move about in are, when a social context is applied, perhaps better be understood in terms of places (Harrison and Dourish 1996) or locales (Fitzpatrick et al. 1996). A place is the understood reality,

e.g. a room, an office or a building, while space only contains spatial measures (Harrison and Dourish 1996). Since we are no longer strictly talking about spaces, but rather about perceived places, i.e. a combination of a physical location and a social context, the notion of range becomes somewhat inappropriate.

Consider for instance a group of people sharing a room, where all participants can talk to and hear each other. This can be seen as a communication cell. Suppose we break the group into two smaller groups. Now we have two smaller cells, independent of each other. This makes very much sense when we only use verbal communication, but current wireless communication devices would not follow these changes as the size of the relevant communication range changes depending on context. This is even more obvious in the case of dividing spaces into different rooms (Fig. 4). Developing technology that communicates within a given place (or part of a place, if that is more appropriate) instead of communicating within a certain space would add new possibilities to this kind of technological support. In other words, we want a notion of "proximity" that is more complex and incorporates more than just the physical distance between things, for instance in what social context they are located. To complicate things, different applications might want to use proximity differently. Sometimes the actual physical (spatial) proximity is preferred, as in the case with the Hummingbirds, while other situations might require more adaptive techniques. Clearly, much remains to be done in this area.

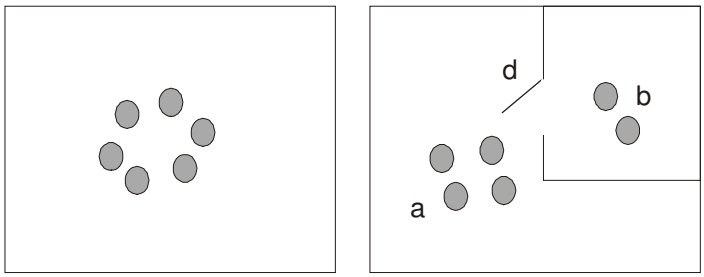

Figure. 4. These figures illustrates the problem of proximity in terms of two different scenarios where different verbal communication ranges apply. In the figure to the left, the

relevant cell encompass all six people; in the right one there are two independent groups (a and b). Further, the degree of independency between the two groups of people partly depends on whether the door (d) is shut or open.

5. Conclusion and Future Work

We have tried to make the case that limited communication range is an interesting constraint when designing support for local interaction. We have also discussed some implications of the experiences we have had with our prototypes and discussed the ideas that have arisen during this work. As we have tried to argue, there are a number of interesting properties associated with local interaction between devices, for instance aspects such as information filtering and the possibilities of transparent human-computer interaction.

We have mentioned future projects such as dynamic and context-sensitive to-do-lists and supporting people engaging in spontaneous meetings with relevant information that could enhance applications similar to the ones described here. In order to investigate such applications, the design efforts, combined with user studies and evaluations, will continue. Important issues for future projects do not only include exploring new services for local interaction, but also to develop a "smarter" notion of proximity in order to acknowledge properties of space that are of social importance. Some easily perceived cues, like open and closed doors, windows and walls, are within reach. Designs for more subtle properties, such as different groups talking to each other within a certain room, will be harder to achieve. However, having a technology that could cope with such aspects of the context would enhance its usability dramatically, given the purposes proposed in this paper.

The suggested approach will also have to be evaluated on other domains than face-to-face communication. For instance, the easy-to-manage (from certain points of view, that is) nature

of systems composed of communicating and functionally self-contained devices can make it easy for users to create and manipulate their own “smart” environments using a variety of devices. Other important issues in future work include security and privacy issues. So far, the need for authentication or a high security level has been rather small due to the nature of the information distributed. However, when developing other applications those issues must be dealt with.

We believe that support for local interaction is an exciting area. Further development in the areas of wireless networks and mobile computing will make many new types of devices that support local interaction possible.

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Fourth Paper

Proxy Lady: Mobile Support for Opportunistic Communication

Per Dahlberg, Fredrik Ljungberg and Johan Sanneblad

Abstract

Proxy Lady is a mobile system for informal, opportunistic face-to-face communication, running on a PDA equipped with a radio transceiver. “Opportunistic communication” is anticipated by one party but it only occurs when the parties happen to meet each other. Proxy Lady supports such communication by providing notifications about possible “candidates for interaction” in the environment. The user specifies ”candidates for interaction” by associating “people” with an “information item” (currently an email or a task). When “candidates for interaction” enter the proximity of the user, Proxy Lady notifies and makes the “information item” accessible. According to our fieldwork, evaluation sessions, and a literature survey, “opportunistic communication” is an important type of communication that has not been supported previously. This paper describes the interface and use of Proxy Lady and the results from an evaluation study.

1. Introduction

The importance of informal face-to-face communication "to get the work done" in organizations has been reported frequently in the literature (Whittaker et al. 1994, Kraut et al. 1990). Our focus is on information technology (IT) support for informal face-to-face (as opposed to remote) communication that is work-related (as opposed to, e.g., purely social). We focus on the face-to-face setting because:

- Most empirical studies that have documented the benefits of informal communication have studied the face-to-face setting (e.g., Whittaker et al. 1994, Kraut et al. 1990).

- Design oriented research on the topic has to a very large extent been concerned with the remote setting (e.g., Bly et al. 1993, Isaacs et al. 1996).

The particular type of informal communication on which we focus is what Kraut et al. (1990) call "opportunistic." Opportunistic interaction is anticipated by one party, but it only occurs when the parties happen to meet each other (Kraut et al. 1990). The main reasons why we focus on "opportunistic" interaction are:

- Our fieldwork (Bergqvist et al. 1999) documented the importance of such interaction.

- It is poorly supported by current systems.

The objective of our research is to explore new and innovative ways of supporting opportunistic, informal face-to-face communication with IT.

In this paper, we describe the design of a system called "Proxy Lady" that supports this particular type of interaction. Proxy Lady assumes that "information items" like emails and tasks can serve as the basis for informal interaction. For example, one reason why Bob may want to approach Joe (when they happen to meet each other) is that he wants to discuss an

email he received from him previously. Proxy Lady lets the user associate information items (currently emails and tasks) with other people, called "candidates for interaction." When a "candidate for interaction" is in the proximity, Proxy Lady notifies and provides the user with the information item (the email or the task). If suitable an informal communication session may follow. According to three formative evaluation sessions (Patton 1990, pp. 155) and a larger evaluation in a real use setting, the use of proximity between people seems to be a novel and promising strategy to facilitate informal interaction in organizations.

The rest of the paper is structured as follows: Section 2 describes the objective and focus of the research. Section 3 introduces the Proxy Lady system, its user interface, use and architecture. Section 4 reports the results from the three formative evaluation sessions we have conducted. Section 5 relates Proxy Lady to previous research on the topic, while sections 6 and 7 discusses and concludes the paper.

2. Objective and Focus

Informal communication is synchronous face-to-face interaction that is brief, unplanned, and frequent (Whittaker et al. 1994). It can be strongly related to work, but it can also be purely social (Gaver et al. 1992). Our focus is on the first category. In a recent field study we found two main characteristics of such "work-related" informal communication (see Bergqvist et al. 1999 for detailed information about the fieldwork):

- The interaction tends to have a "closed agenda:" only a few topics are addressed. Informal communication in general has an "unarranged agenda" (Kraut et al. 1990)

- Only people concerned with the topic tend to participate. Informal communication in general can have "random participants" (Kraut et al. 1990).

We also observed that these informal sessions are frequent, and that they often involve a small group of people (often two or three, not more than five).

Informal communication is serendipitous (Kraut el al. 1990). A common example in the literature is two people meeting each other in the hallway; they start to chat and exchange valuable information (e.g., Gaver et al. 1992). The session is not convened, nevertheless it is important.

Whittaker et al. (1994) identify two categories of systems that support informal communication: First, permanent open links between distributed common places, e.g., "VideoWindow" (Fish et al. 1990), and second, desktop video systems, e.g., "CAVECAT" (Mantei et al. 1991). These systems all try to enable remote people to communicate informally without having to meet each other face-to-face. So far, however, it has been difficult to establish the same quality of informal communication in the remote setting (Isaacs et al. 1996). One reason may be that the remote setting removes the distance between people; everybody is equally close (or far) from each other (Obata et al. 1998).

Some recent projects such as Thinking Tag (Borovoy et al. 1996) and Hummingbird (Holmquist et al. 1999), have explored the face-to-face setting of informal communication. These projects focus on spontaneous, unanticipated interaction, which is related to but yet different from the type of interaction on which we focus, called "opportunistic." The main difference is that "opportunistic interaction" is anticipated by one party, however it only occurs when the parties happen to meet each other (Kraut et al. 1990).

Our approach to support informal communication is based on the idea of notifying of candidates for interaction in the proximity. In many modern offices people are in the proximity of many others during the working day. We want them to become aware of proximate colleagues with whom they may want to interact. The strategy we use to filter "candidates for interaction" is to let people select with whom they want to discuss a particular information item (an email or a task item). When the user is close (within the "area of proximity") to a "candidate for

interaction" the system notifies, and (if suitable) an informal communication session may occur.

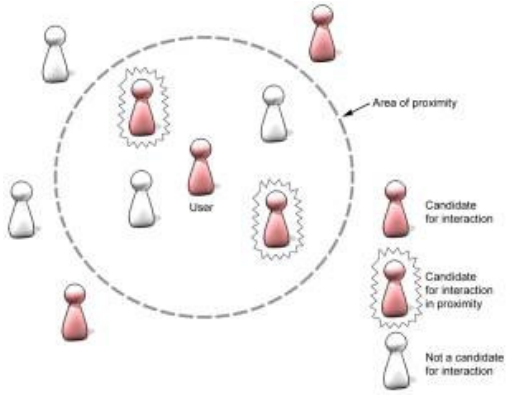

Figure 1. Using proximity to detect "candidates for interaction."

In order to detect "candidates for interaction" the mobile platform needs to be "location aware" (see figure 1). However, it does not need to know where it is (absolute position), only its relative location to other devices (relative position).

"Location awareness" may be viewed as a simple instance of "context awareness." A context aware system collects data about its environment and adapts its behaviour accordingly (Shilit et al. 1995). While location aware systems only collect data about the absolute or relative location, context aware systems may collect data about the history of user operations, the weather, the location, etc.

To sum up, our focus is on opportunistic informal communication in face-to-face settings. Our objective is to enhance and facilitate such interaction by means of IT. Our strategy is to match "candidates for interaction" with the proximity between people. Next we describe Proxy Lady, which is the IT platform we have designed to provide such support.

3. Proxy Lady

Proxy Lady is a mobile system for informal, opportunistic face-to-face interaction, running on a PDA equipped with a radio transceiver. In this section, we describe the use, interface and architecture of Proxy Lady.

3.1 Use scenario

The following scenario demonstrates the type of informal communication that we seek to facilitate with Proxy Lady.

> "Bob arrives at his office one morning. He turns on the PC and checks new emails. One email is from Joe. It concerns a project they may launch jointly later this year. They have discussed the issue previously. However, they did not go into details and no decisions were made. Now Joe wonders what to do. "Did you talk to the client? Does Jane know about this? Does the project actually match the new company strategy? Will we have the resources needed?" Etc.
>
> The message raises several open and important issues, but it is not urgent. Since Bob and Joe meet rather frequently, Bob makes the decision to address the project the next time they meet. In order not to forget, he wants the Proxy Lady client to help him. He selects the message, which is immediately transferred to his Proxy Lady client. Bob's PDA beeps; it is time for the weekly group meeting. He leaves the office and heads towards the meeting room.
>
> On the way back from the meeting Bob receives a notification from the Proxy Lady client (running on his PDA). Proxy Lady tells him Joe is in the proximity. Bob looks around and notices that Joe is entering the office corridor (approximately 20 meters away). Since he has no appointment and Joe does not look very busy, Bob thinks this may be a good opportunity to talk about the project. Therefore, he approaches Joe saying: "Hi there! I received your email about the project. Do you have a minute?" "Sure," Joe replies, "let's

sit down in the coffee room and sorts things out." The interaction lasts for five minutes."

The three main situations of the scenario are:

- (A in figure 2) Bob wants to discuss the project with Joe when they meet. He marks the email, which is transferred to his Proxy Lady.
- (B) Proxy Lady notifies Bob that Joe is around. Since Bob finds it suitable to talk about the project, and Joe does not look very busy, Bob makes the decision to approach Joe.
- (C) Joe accepts the invitation and an informal communication session follows (during which Bob may consult the email).

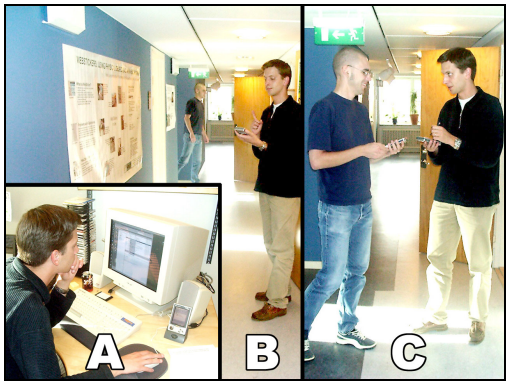

Figure 2. Three basic situations of the use scenario.

In figure 2, we illustrate the three main situations of the scenario.

We will now describe how the Proxy Lady system is operated from a user's perspective.

3.2 Interface and Use

There are two main interface components of Proxy Lady: the desktop and the PDA. Let us now describe these in some more detail.

3.2.1 The desktop

If the user of Proxy Lady for some reason wants to discuss an email with a person, then she needs to associate it with that person. To associate an email with a person, the user makes a copy of the message to a dedicated folder (called “Proxy Lady”) on an IMAP server. To make the copy, the user selects the message, presses the right mouse button, and pastes it in the “Proxy Lady” folder (see figure 3).

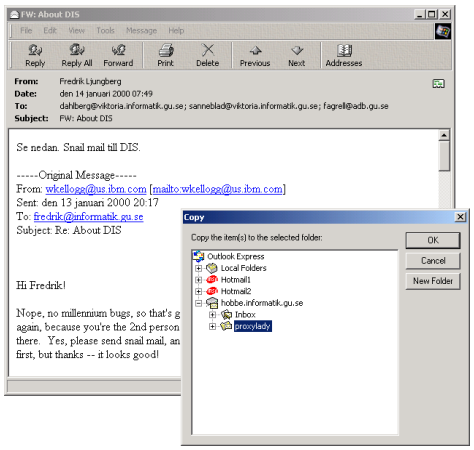

Figure 3. Associating emails with Proxy Lady.

Proxy Desktop manages the flow of information between the email client and the PDA. At regular intervals the Proxy Desktop scans the “Proxy Lady” folder on the server. It converts emails to information items and transfers them to the PDA. The Proxy Desktop lists items that are not yet synchronized. Figure 4 shows an example of the Proxy Desktop.

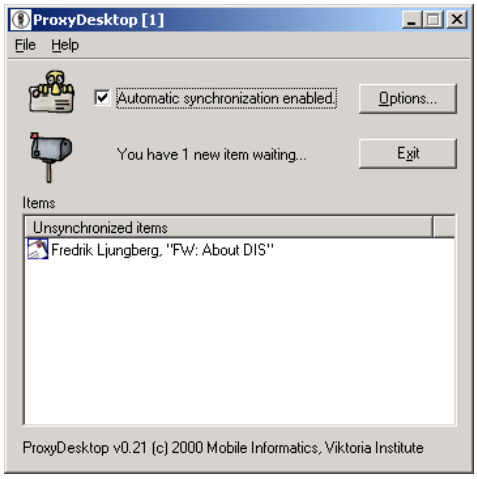

Figure 4. The Proxy Desktop component.

When the option "Automatic synchronization enabled" is chosen, the Proxy Desktop transfers the new email items to the client the next time the PDA is connected to the PC. Four new messages, like in the example above, will only take a few seconds to transfer to the PDA. Now, the email items that the user wants to discuss with other people will be used by the Proxy Client.

The PDA: The main window of the mobile client (Figure 5 a) lists "candidates for interaction," i.e., the names of people with whom the user has associated emails. The "candidates for interaction" are either within the proximity ("Contacts in proximity…") or away ("Contacts away…").

The number previous to each name tells the user how many items she has associated with the person in question. The user taps the name (5b) to view the subjects of the items. By tapping a subject in the list, the properties of the matching information item are displayed on the screen (5 c).

When a "candidate for interaction" enters the proximity of the user she becomes notified by a "proximity alert."

The "proximity alert" makes three things happens (5 d):

- A sound. The sound can be changed and turned on/off.
- A flashing light that can be turned on/off.
- The name of the person is displayed in a dialog box.

The user can create email and task items on the PDA. The reason why Proxy Desktop only supports email items is that tasks and other information used by common groupware applications often have proprietary standards demanding dedicated solutions.

The user starts and stops the client by selecting “Visible” or “Invisible” in the dropdown menu at the right-hand top corner (Fig. 5 a).

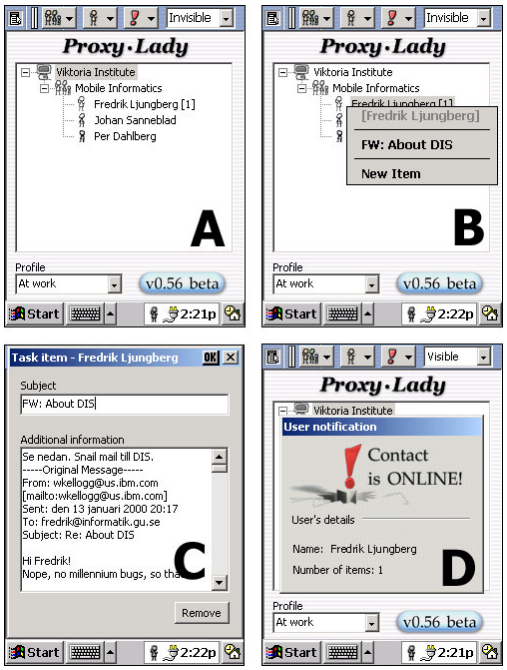

Figure 5. The Proxy Client user interface.

3.3 Implementation

Proxy Lady was implemented on the Windows CE (version 2.11) platform using Visual C++ and Microsoft Foundation Classes (MFC). Using Visual C++ and MFC we were able to develop a solid and reusable software platform with code that could run on both a PDA and a desktop computer (Proxy Desktop shares more than 50% if its code with the Proxy Client). We developed the software using a layered architecture that separates user, business, and data objects.

3.3.1 Software platform

In figure 6 we illustrate the main components of Proxy Lady.

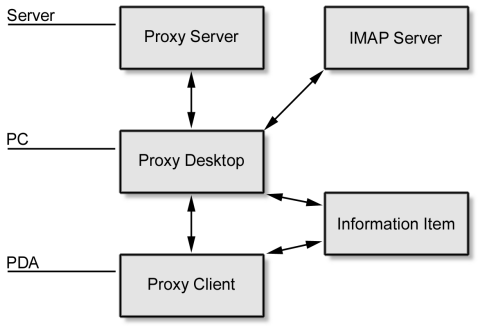

Figure 6. The components of Proxy Lady.

Proxy Server manages a list of users of the system. The list comprises ID, name, and email addresses. The ID is a unique number that the system assigns to the users (when registered). It is used by the Proxy Client in the process of identifying "candidates for interaction." Updates to the list are transferred to the Proxy Client as soon as the PDA is connected to the PC.

Proxy Desktop exchanges information with the Proxy Server and imports email items from a central IMAP server. Because we developed our own IMAP client using MFC we can easily port all functionality to Windows CE when permanent network connections become available.

Proxy Client contains interface components for displaying, modifying and notifying "candidates for interaction." It uses a shared file folder to synchronize with the desktop (using Microsoft's proprietary ActiveSync software).

Information Items are used for storage and information transfer between Proxy Desktop and Proxy Client, and contains the association a user creates between a person and an information entity. An information item is an abstract entity that we so far have realized through two specializations: emails and tasks. Adding new specializations in the future will be easy due to the object-oriented approach we have chosen.

3.3.2 Hardware

Proxy Lady has three types of hardware components: PDAs (Cassiopeia E-105) equipped with radio transceivers (see figure 7), PCs, and a server. The radio transceivers manage the scanning of the area of proximity. The scanning range is today set to 20 meters (in an open environment).

In the current version of Proxy Lady the hardware for short-range communication is customized. This is likely to change in future versions of the system due to the development of standard radio components like Bluetooth.

Figure 7. The Proxy Client hardware.

4. Evaluation

In order to assess Proxy Lady, we conducted workshops and user studies:

- A design workshop during the design phase of the system, which aimed at helping us refine the design before the user trial.
- Observations of the system in use
- Closing workshops with the users and selected colleagues (who had experienced the system in use in the organization, but had not used the system themselves)

We used video to capture the workshops and took notes during the observations. We transcribed all the data we had collected. The data was analysed using a grounded theory approach (Glaser and Strauss 1967). We went through the data repetitively and marked important events. Gradually we identified the categories that appeared most relevant. The results of the investigations concern the concept of Proxy Lady and ideas for improvements. The categories are presented in section 4.3 and 4.4. When possible, we have tried to articulate the differences between the different groups. However, in many cases the type of feedback we received was homogenous between the groups.

The research approach adopted by the research we present in this paper has been called "The New Informatics" (Dahlbom 1996) or when applied in the mobile domain, "Mobile Informatics" (Dahlbom and Ljungberg 1999). The overall idea of this genre of Informatics research is to contribute to "innovation" within the field of IT use. This means that we aim at novel but yet realistic suggestions of how IT could be used within the domain of interest.

The practical orientation of this type of research has been questioned. Is not this what practitioners are supposed to do? Are not researchers supposed to observe and come up with theories? Our claim is not that all informatics research should be practical and design oriented. What we do argue, however, is that our field should open up for more innovation-oriented research. Otherwise, we do run the risk of becoming too much detached from "where the action is."

4.1 The Design Workshops

The workshop sessions involved three different groups:

- Group A: A team of three systems administrators (at our department at the university)
- Group B: A team of three groupware consultants.

- Group C: Two salesmen and three department managers at an IT consulting agency.

The objective of the workshops was to assess the potential use of the system in different mobile use settings.

The three user groups shared many features with the intended users of the system. For example, they meet many people, that are mobile during the working day, and they are involved in much communication. We assume these to be typical conditions under which future users of the system will work. For this reason, however, the results of the evaluation may not be generally applicable, simply because we do not know how Proxy Lady would work in other settings like schools, factories or rock concerts. Since our aim is to support professionals involved in much communication, the selection of workshop participants seemed appropriate.

The workshops were based on the pluralistic walkthrough approach (Bias 1994). Pluralistic walkthrough is related to cognitive walkthrough and "jogthrough" (Nielsen and Mack 1994). It advocates an open discussion between designers, usability experts and users, investigating the usability of the steps associated with a specific task scenario. The user session of the systems administrators explored "helping users," the groupware consultants "cooperating while working in a project," and the IT consulting agency "organizational communication." During the workshops the participants were able to comment on anything they came up with, even if it did not relate to the specific task scenario. We used a digital video camera to capture all workshop-sessions. The videos were also transcribed.

4.2 Evaluation in Use

The user studies that followed the initial workshops investigated the use of Proxy Lady in a real use setting. At the site where we made the study, we equipped five employees with Proxy Lady clients. The research site is an IT consulting agency (not related

to our research department), with about 40 employees (at this particular site). During the trial period, only four were actually able to use the clients, since one person experienced technological problems. The radio transceiver simply stopped working and we did not manage to repair it.

The professional roles of the people who tried out the system includes: a project leader, a systems developer, a manager and a business developer. When we provided the users the Proxy Lady clients, we gave them a brief introduction to the system. We conducted observations during approximately 20 hours during a three-week period. We took notes continuously, all of which we later transcribed.

4.3 Closing workshops

The people who the user study concerned, we also involved in a final workshop session (Group D). The final workshop involved the four people who had used the system, and two who had not. To distinguish between these two groups of people, we use the following categories:

- Group D Users: People who had used the system.
- Group D Non Users: People who had observed the system in use.

We involved non users in the workshop to investigate the views of people who on one hand had experienced the system in use – their colleagues had used it, which they knew, but on the other had not actually used it themselves. The final workshop was also videotaped and transcribed.

4.4 Results concerning the concept of Proxy Lady

Below we summarize the main issues regarding the concept of Proxy Lady. The categories were formed based on the results from the empirical work.

- The task domain was recognized and considered important

Everybody recognized the kind of tasks that Proxy Lady seeks to support. Furthermore, there was a general agreement that these tasks are important. Clearly, this observation is very important, because it indicates that the research addresses situations that people understand and where they think they may need help. Even though this was hinted in the empirical research based on which the concept of Proxy Lady was coined (Bergqvist et al. 1999), this confirmation was really important.

Comments from the users in Group A-C, who had not experienced the actual system in use, were similar to each other. One of the salesmen in Group C said: "It is difficult to remember what to say when you meet people." Another salesman said: "E-mail is very good. It often happens that you mark an email to follow it up later, but forget about it when you meet people."

One participant from Group D Users said: "…It is a good step to take, it is so darn logical and we know that we will take it." As always, this observation may be limited to the domains we investigated. Nevertheless, the result is positive.

- Positive attitude

A similar observation is the positive attitude of people towards the system. As a matter of fact, everyone involved in the user studies was positive towards the system and thought it may help them doing their work more effectively.

People who did not have the opportunity to use the system (Group A-C, and Group D Non Users) all wanted to try it out. One of the groupware consultants in Group B said: "I think it would be interesting. I don't know in what form though. But I would like a tool like this." A salesman in Group C said: "The

number of tasks each person has to manage currently surpasses ones ability."

One of the Group D Users commented on integrating a system supporting opportunistic interaction into everyday work: "…this has shown that it is possible; we have come that far now. Sure, it will work".

- Physical constraints

Obviously, Proxy Lady would mean "yet another device" for people who do not use the Cassiopeia PDA (which was the only platform on which the system was available at the time of the studies). For obvious reasons, the participants did not want to use two or more devices (this was the case for both people who had used the system and those who had not).

Participants in Group B and Group C who had not tried out the system and were using other types of PDAs said they probably would need to migrate to the Cassiopeia when adopting Proxy Lady. One of the groupware consultants in Group B said: "It would have to be embedded in a bracelet or something. A ring perhaps?" The System Administrators in Group A were reluctant both to the thought of switching PDAs for the Cassiopeia, or using two devices.

When discussing the use of a "Proxy Lady-equipped" Cassiopeia PDA, one of the Group D Users said that "the size was less important than the fact that the radio transceiver made it impossible to recharge or synchronize the PDA with the PC." Further, the quality and reliability of the transceivers were not sufficient for a production environment. The participant in Group D Users that was given the malfunctioning transceiver commented that we were doing the evaluation with premature technology.

- Privacy issues

People who had not used the system (participants in Group A-C, and the people in Group D Non Users) expressed concerns for potential misuse of the system, e.g., that people could monitor

each other. However, they all seemed satisfied with the “invisible mode.” An interesting twist on the privacy issue is that Proxy Lady can be used to prevent interaction. One of the System Administrators said: “Oh great, then I can be notified of annoying users, and just run the other way or close my door.”

During our observations we found no situation where the privacy of the user was threatened. However, the period of use was probably too short to reveal such situations. During the workshop, none of the people in Group D Users expressed any concerns regarding potential misuse of the system.

- Disruptions

The people in Group A-C who had not seen the system in use expressed some concerns regarding the possibility of disruptions. One salesman in Group C said: “There is a risk that the day is becoming fragmented. It is difficult to anticipate how one would act.” A manager in the same group said: “The question is how event driven you want to be. Some feel that we already are too event driven.” One consultant in Group B said: “You don’t want to be too controlled, then you run the risk of missing the informal part of communication.”

One workshop participant in Group D Non Users remarked that Proxy Lady might be yet another device interrupting his work. However, his colleagues who actually had used the system did not agree, arguing: “It’s not as disruptive as a mobile phone. It is a bit ‘softer’.” By softer they meant that it is easier to ignore Proxy Lady when it notifies the user, compared to a mobile phone. Further, one of the users claimed that disruption can actually be a positive property, depending on your role in the organization, “It is another device that calls for your attention, in the same way as mobile phones does; when it rings you have to deal with it. But in my professional role this is not a bad thing. On the contrary, it is often such events that lead to positive results…,” the business developer in group D commented.

4.5 Results concerned with how to improve the system

Below we summarize the main issues regarding how to improve the system as such.

- New information items

During the workshops with Group A-C, web pages, documents and files were suggested as new types of information items to support (in the list of information items). These types of items were actually suggested by all workshop groups. One of the consultants in Group B also suggested that: "Information Items should also be linked to their current ERP system."

The users in Group D who had seen the system in use, however, seemed to be satisfied with the "task" information item type (during the concluding workshop no participant had any suggestions of new items).

- Notification of artefacts

Several participants of group A-C expressed that it might be useful to associate information items not only with people, but also with things like computers. For example, one of the Systems Administrators in Group A claimed he wanted to be reminded (notified) about making software upgrades when walking by a workstation.

- Range of proximity

The users in Group A-C who had not seen the system in use requested different ranges of proximity. One group wanted a range of 10 meters, another a range of 50 meters. It may also be useful to specify the range of proximity for different people. For example, one groupware consultant claimed: "If a person who you usually don't meet is in the same building, you would like the Proxy Lady to notify. But if it is your colleague next door, you don't want to know." All users in Group D, however, claimed that the range was sufficient.

- Hardware hassles

Unfortunately, the current implementation suffers from some technological problems:

- The transceiver is a bit too large
- The PDA cannot be recharged without removing the transceiver
- The transceiver consumes much power
- The transceiver is fragile

These problems caused some hardware hassles during the trail period. However, the objective of this project was not hardware design, but to explore and try out the concept behind Proxy Lady, i.e., IT support for opportunistic communication. Therefore, the hardware shortcomings were perhaps not so serious for our purpose here.

- Users and non users

People who had not used the system had more innovative and radical comments for redesign, compared to people who had actually used the system. For example, the former wanted features to adjust the range of the system, while the actual users were satisfied with the fixed range. Many of the people who had not used the system also suggested new types of information items, while the users thought it was enough with the available information items.

One reason for this might be that it is difficult to picture what functions are useful in a real use situation. Another reason could be that when a person becomes used to a system, she might be used to its limitations and learn how to overcome the shortcomings. The task information type, for instance, is flexible, in the sense that it can store all types of text. This makes it possible to paste addresses to web pages, together with some of the texts of the web pages. The problem with the fixed range, on the other hand, might not have been a problem in a real use setting.

However, it is difficult to make a proper analysis on what the reasons might be for the differences between the users and the non users. Other possible reasons might be that the users were so focused on the hardware hassles that they did not manage to come up with suggestions for future functionality or simply that the users were not in a creative mode during the time of the workshop.

5. Related Work

In this section we compare and contrast Proxy Lady with similar research in two main areas: memory aid systems and interaction support systems.

5.1 Memory aid systems

Memory aid systems like Forget-me-not try to "help with everyday memory problems" (Lamming and Flynn 1994), e.g., recalling a name or finding a document. Forget-me-not seeks to help people retrieve information they once knew, e.g., when something happened, by using context as retrieval key (e.g., Lamming and Flynn 1994). The system creates "biographies" for the users by capturing who they meet (relative location), where they go (absolute location), and other "contextual data." The idea is that we organize our memory about the past in episodes, and that the location, who was there, etc., are "strong cues for recall." Forget-me-not provides people with such cues as a means to help them to remember (e.g., where a document is). Even though there may be similarities between Forget-me-not and Proxy Lady on a systems level, the types of activities the systems seek to support are very different (memory aid vs. support for informal communication). Forget-me-not runs on PARCTABS, which is a mobile, ubiquitous computing platform

(Want et al. 1995). PARCTABS could have served as the technological infrastructure of Proxy Lady.

The Wearable Remembrance Agent is a wearable, ubiquitous memory aid system that shares features with Forget-Me-Not (Rhodes 1997). However, the Wearable Remembrance Agent uses a head-up display for systems output (not a screen), it relies on other contextual clues, and it is more proactive. Compared to Proxy Lady, the Wearable Remembrance Agent has another objective: it is a memory aid system, not a tool for informal communication.

5.2 Interaction support systems

We have identified two types of interaction support systems that are related to, but yet different from Proxy Lady. These are systems supporting intended and spontaneous interaction between people in face-to-face settings.

Active Badge is a mobile system that helps people to find colleagues and transfer telephone calls (Want and Hopper 1992). Badge systems (also implemented at Xerox, MIT, etc.,) support "intended" interaction, i.e., situations where someone explicitly tries to find a colleague (Isaacs et al 1996). Proxy Lady, on the other hand, was designed to support "opportunistic" communication, i.e., communication that is anticipated by (at least) one participant, but occurring only when the parties happen to meet (Isaacs et al. 1996).

In contrast to intended interaction is spontaneous interaction that is unanticipated. Examples of systems supporting spontaneous interaction are Hummingbird and Thinking Tag.

Hummingbird is a mobile device that aims to support awareness between group members who are in the physical vicinity of each other (Holmquist et al. 1999). A Hummingbird scans its surrounding (approximately 100 meters range) for other Hummingbirds. It tells its user ("it hums" and displays the name on a screen) when another device has been detected. The

Hummingbird system and Proxy Lady may also look similar on a systems level. However, the systems are different: Hummingbird seeks to maintain general awareness in (mobile) groups to support spontaneous interaction, while we want to increase the frequency and quality of opportunistic, informal communication.

A system related to Hummingbird is the Thinking Tag, which is a wearable, context sensitive nametag (Borovoy et al. 1996, Borovoy et al. 1998). It displays the name of the person wearing it (just like an ordinary nametag), but also the extent to which she has picked the same answers to five multiple-choice questions as the people she meets. The five questions are represented by five diodes on the Tag. A green diode means that two people have answered the same to a question, a red that they have not. The Thinking Tag seeks to augment the social processes of people mingling at conferences (and similar events) by augmenting spontaneous, unanticipated interaction. Accordingly, it is less work-related than Proxy Lady.

6. Discussion

Privacy issues and the problem of disruption have been discussed frequently in the literature on systems supporting informal communication. Obviously, they also need to be considered carefully in the case of Proxy Lady. Let us start the discussion by exploring these issues in some more detail.

6.1 Privacy and disruption

Systems that support informal communication may be perceived as disruptive and a threat against privacy. For example, consider the following quote from Hudson and Smith (1996, p. 248):

> "…the more information about oneself that leaves your work area, the more potential for awareness of you exists for your colleagues. Unfortunately, this also represents the greatest

> potential for intrusion of your privacy. Similarly, the more information that is received about the activities of colleagues, the more potential awareness we have of them. However, at the same time, the more information we receive, the greater the chance that the information will become a disturbance to our normal work."

The problems of privacy and ethics of "invasive technologies" such as Proxy Lady and Media Space systems have been discussed frequently in the literature (e.g., Anderson 1991, Bellotti and Sellen 1993). Clearly, these problems are important and they need to be taken seriously.

Because Proxy Lady is based on relative location, the potential misuse of the system seems less than systems based on absolute location, e.g., Active Badges. In fact, one user claimed he could use Proxy Lady to increase privacy by letting the system warn of annoying people coming nearby.

Technically, users of Proxy Lady could simply activate the "invisible mode" to disappear when suitable. However, this would not always be enough. For example, what if using the "invisible option" is against the ways in which the system could be used intelligibly in the organization? In such a situation, users who turn off the system would be expected to come up with "a good reason why." Otherwise, turning off the system would mean breaking an unwritten law requiring an explanation.

Since intelligible use patterns partly derive from the social context of the organization, sometimes called "the corporate culture," issues like privacy and ethics cannot be handled technologically exclusively. In other words, a feature like the "invisible mode" of the Proxy Lady system can hardly solve the problem, even though it can be helpful. So, when introducing an "invasive technology" like Proxy Lady, what social rules would be defined, how could "good rules" be assured?

The social rules that define intelligible and not intelligible use of technology derive from complex organizational processes, which have been researched frequently within our field. One further case for this strand of research could be the adoption

and use of the Proxy Lady system. The initial evaluation studies we report in this paper clearly need to be completed with additional empirical data. However, that is not the main topic of the research reported in this paper, i.e., the rationale and design of a novel mobile system based on relative location between mobile personnel.

The problem of disruption has also been reported from studies of informal communication systems. Attempts to make systems less disruptive include trying to simulate how people approach each other in the real world (Tang et al. 1994). One strategy to cope with disruptions is (once again) the "invisible mode," which makes it easy to disappear when experiencing too many annoying interruptions. However, as noted above this strategy is primitive. Other possible solutions are filtering (who to notify) and the use of ambient media (Ishii and Ullmer 1997).

As the discussion above implies, the success or failure of a system like Proxy Lady to a considerable extent relies on the social use context of the user organization. Questions you then may ask are:

- What is a typical example of a social context within which Proxy Lady would be a success?
- What is a typical example of a social context within which Proxy Lady would be a failure?
- What is a typical example of a social context within which Proxy Lady would be misused?

These questions are serious, and you could of course have hypotheses regarding the possible answers. For example, inasmuch as using Proxy Lady as a control tool is regarded as "misuse" of the system, we could suspect this could happen in an organization characterized by, for example, a management culture that says anonymous control of workers is legitimate. The other way around, we could assume that a company with a flat organization, where management supports spontaneous cooperation and the workforce is empowered, could be an

example of a user organization with the "right preconditions." However, to us it seems risky to speculate too much about this without empirical data. That is, future empirical investigations of Proxy Lady in use will have to be conducted to find out.

6.2 The problem of proximity

Proxy Lady uses the relative proximity between users to notify "candidates for interaction." Using the terminology of Harrison and Dourish (1996), the system is based on "space," not "place." "Space" is the three-dimensional world of objects and events, while "place" is "the understood reality" (Harrison and Dourish 1996, p 69):

> "It is a sense of place, not space, which makes it appropriate to dance at a Grateful Dead concert, but not at a Cambridge college high table; to be naked in the bedroom, but not in the street... [..]. Place, not space, frames appropriate behaviour."

Accordingly, the notion of proximity on which Proxy Lady is based could be problematic (see also Redström et al. 1999). For example, a user could be notified that a "candidate for interaction" is in the proximity when she in fact is in an office on the next floor. In this case, being 3 meters away is not being in the proximity simply because those three meters are vertical.

According to the workshop sessions, different use situations require different radius of the area of proximity. This implies that the radius should be easy to adjust. One option to explore further is default radius modes. For example, the "large office landscape" mode could have a radius of 50 meters, "small office" 20 meters, and so on. Another option to explore is the possibility to adjust the area of proximity for different users or type of users. For example, you may always want to be notified when Jimmy Connors is less than 500 meters away, or when someone in the board is nearby.

One way to turn space more into place would be to "annotate" (or "tag") space and use positioning techniques. This

would make it possible to know if someone is in Nick's office, the kitchen or the meeting room. However, representations are always simplifications. For example, they cannot tell you whether or not it is appropriate to interact, which may be very important (Kristoffersen and Ljungberg 1999).

Even though Proxy Lady makes simplifications about the world it may still be a useful interaction tool. For example, communication systems like ICQ, which makes many simple (and arguably naive) assumptions about human conduct, is still very useful. The important point may be that users can learn and understand the simplifications. This is an important issue for a long-term evaluation study.

7. Conclusion

We have introduced the Proxy Lady system supporting opportunistic, informal communication in face-to-face settings. By using relative proximity between people and "candidates for interaction," obtained through explicit user actions, the Proxy Lady system supports informal sessions in the workplace. In doing so, the system aims to support a valuable asset of work: opportunistic communication.

The main contribution of Proxy Lady is its support for opportunistic communication in face-to-face settings. It is an interactive system that addresses previously unexplored use situations. Previous systems supporting the face-to-face setting either focus on spontaneous (e.g., Borovoy et al. 1996) or intended interaction (e.g., Want and Hopper 1992). The objective of augmenting informal communication as opposed to "help with everyday memory problems" makes Proxy Lady different from memory aid systems like Forget-me-not (Lamming and Flynn 1994). Reviewing the literature we may also claim that using relative proximity to support interaction between people is a novel approach.

The informal workshop sessions we conducted reported promising results. Even though there are issues to consider in re-design, Proxy Lady seems to be a useful, lightweight interaction tool that people are willing to use in their work.

There are several upcoming standard components for short-range communication, e.g., Bluetooth. The Proxy Lady project could be viewed as an attempt to start exploring one type of applications that such components will realize.

Future work involves a long-term evaluation study of Proxy Lady in use. Previous to that, we need to redesign the transceiver platform to be more robust and easy to operate. We also need to update the software design according to the evaluation results, as well as redesign the software for the latest version of Windows CE (called Pocket PC).

8. Acknowledgements

This research has partly been funded by SITI.

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Fifth Paper

The use of Bluetooth enabled PDAs: Some preliminary use experiences

Per Dahlberg

Abstract

There have been a lot of discussions about the use of Bluetooth technology. However, not very much practical experience on the use of the technology has been reported. This paper reports from users trials of an application built for Bluetooth: Proxy Lady. Proxy Lady is a support for "opportunistic interaction." The system notifies when people the user wants to talk to enter the proximity. The use of the system is discussed, including privacy issues, suitability compared to other communication channels and possible future directions for this type of software support.

1. Introduction

Recently many different types of equipment have been fitted with Bluetooth technology. Bluetooth is a standard for short-range

radio communication. All major platforms for hand-held devices will probably support Bluetooth natively.

The first generation of use of Bluetooth on PDAs is basically cable-replacing applications. For instance, Ericsson's, one of the initiators of the standard, first products fitted with Bluetooth technology was a wireless "portable handsfree set" and Bluetooth enabled phones. Even though we acknowledge the usefulness of this way of using Bluetooth, it seems clear that the potential of the standard is greater than that. Would it not be possible to design totally new types of applications and services once your PDA is able to communicate with other equipment in the vicinity?

The Bluetooth standard has a limited range of operation. This is often seen as a limitation of the technology. However, the short range gives some interesting implications for design, especially when designing for locally mobile persons. For instance, it is possible to use the short range to detect other devices that are within the range of operation. Systems like the Hummingbird (Holmquist et al. 1999) use the same type of technology to detect people in your proximity. So, if my Bluetooth device detects another Bluetooth device, we can assume that the detected device is close to us.

This paper reports of an application called Proxy Lady that aims to use the limited range as a resource. It uses information of what other people who are in the proximity to notify the user of relevant information. The system is based on a PDA that is equipped with our custom developed radio transceiver.

When the system was designed there were no Bluetooth devices available on the market. In order to design and use applications for Bluetooth, we had to design custom hardware. We designed a radio transceiver with similar characteristics as Bluetooth. By using a standard PDA with the custom radio transceiver, we were able to design new types of applications for the Bluetooth technology without having access to Bluetooth. By testing out these applications under real working conditions, we believe we have gained some insight in what the use of Bluetooth

enabled PDAs might be like. This paper reports from a field study that explores the use of Bluetooth enabled PDAs running the ProxyLady application.

The structure of the paper is as follows. First, we describe the ProxyLady application. Second, after having described our research methodology, we present use experiences from a use trial of the application at a company.

2. Proxy Lady

Fig. 1. The mobile client of the Proxy Lady system.

Proxy Lady aims to support "opportunistic communication" in mobile work settings. A user can associate information items to other users. When those users come in the proximity, ProxyLady fires a notification.

The importance of informal communication has been reported frequently in the literature (e.g. Whittaker et al. 1994, Kraut et al. 1990). Informal communication, such as discussions in the coffee room may involve several types of situations. Fish et al. (1990) defined a number of different situations, or types of informal communication. One of those is "opportunistic interaction." Opportunistic interaction is anticipated by (at least) one party, but it only occurs when the parties happen to meet each other (Fish et al. 1990). Studies show that opportunistic

communication is of great importance, not only to socialize, but also to “get the job done” (Bergqvist et al. 1999).

The Proxy Lady system (figure 1) is a mobile client, implemented on a Casio Cassiopeia E-105 with a custom developed radio transceiver. The system was designed to support “opportunistic communication” in mobile work settings. Proxy Lady assumes that information items like emails and tasks can serve as the basis for opportunistic interaction. The system lets the user associate information items (currently emails and tasks) with other people, making them a “candidate for interaction.” When a candidate for interaction is in the proximity, Proxy Lady notifies and provides the user with the information item. If suitable, an informal communication session may follow.

2.1 Interfaces and use

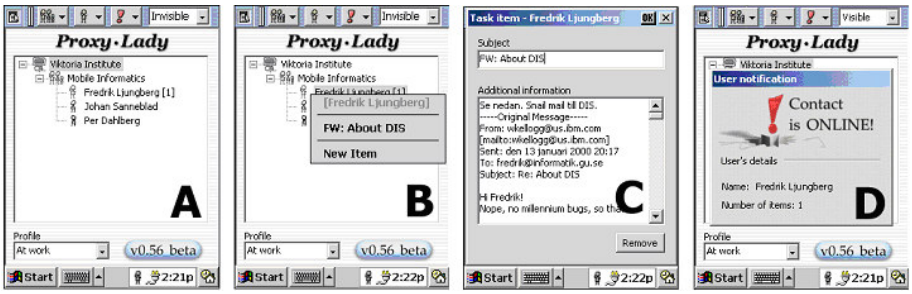

Fig. 2. The Proxy Client user interface

When a Proxy Lady user for some reason wants to discuss an email with a person, she needs to associate it with that person. To associate an email with a person, the user makes a copy of the message to a dedicated folder (called “Proxy Lady”) on her email client. The Proxy Lady desktop software transfers the item to the mobile client once it is connected. Tasks are created directly on the mobile client, by clicking on “New Item” (Figure 2 b).

The main window of the mobile client (Figure 2 a) lists the names of people in the contact list. The contacts can be

categorized into categories and sub-categories. When a contact is in the proximity, her name is bold. The number that follows some names tells the user how many items she has associated with the person in question. The user taps the name (2 b) to view the subjects of the items. By tapping a subject in the list, the properties of the matching information item are displayed on the screen (2 c). When a person who has an item associated with her enters the proximity of the user, she gets a "proximity alert." The "proximity alert" (2 d) can be mediated through a sound, a flashing light and a dialog box. The user can activate an "invisible mode" by selecting "Visible" or "Invisible" in a drop-down list (see figure 2). The "invisible mode" hides the user for others.

2.2 Architecture

ProxyLady was implemented on the Windows CE (version 2.11) platform using Visual C++ and Microsoft Foundation Classes (MFC). Using Visual C++ and MFC we were able to develop a solid and reusable software platform with code that could run on both a PDA and a desktop computer (the PC code shares more than 50% if its code with the Proxy Lady code). We developed the software using a layered architecture that separates user, business, and data objects.

The system includes a server (Proxy Server), a desktop component (Proxy Desktop) and the actual PDA application (Proxy Client, or simply ProxyLady). Proxy Server manages a list of users of the system. The list comprises ID, name, and email addresses. The ID is a unique number that the system assigns to the users (when registered). It is used by the Proxy Client in the process of identifying other users. Updates to the list are transferred to the Proxy Client as soon as the PDA is connected to the PC. Proxy Desktop exchanges information with the Proxy Server and imports email items from a central IMAP server.

Proxy Client contains interface components for displaying, modifying and notifying "contacts." It uses a shared file folder to

synchronize with the desktop (using Microsoft's proprietary ActiveSync software).

Information Items are used for storage and information transfer between Proxy Desktop and Proxy Client. They contain the associations users create between a person and an information entity. An information item is an abstract entity that we so far have realized through two specializations: emails and tasks.

Proxy Lady has three types of hardware components: PDAs (Cassiopeia E-105) equipped with radio transceivers, PCs, and a server. The radio transceivers manage the scanning of the area of proximity. The scanning range is about 20 meters (in an open environment).

2.3 Related Systems

Before reporting the field data from the user trials of Proxy Lady, let us briefly go through related systems, described in the literature.

Memory aid systems like Forget-me-not try to "help with everyday memory problems" (Lamming and Flynn 1994), e.g., recalling a name or finding a document. The system creates "biographies" for the users by capturing who they meet (relative location), where they go (absolute location), and other "contextual data." Forget-me-not runs on PARCTABS, which is a mobile, ubiquitous computing platform (Want et al. 1995). PARCTABS could have served as the technological infrastructure of Proxy Lady. The Wearable Remembrance Agent is a wearable, ubiquitous memory aid system that shares features with Forget-Me-Not (Rhodes 1997). Those systems are memory-aid systems, as opposed to Proxy Lady that aims to support interaction between people.

Active Badge is a mobile system that helps people to find colleagues and transfer telephone calls (Want and Hopper 1992). Badge systems support "intended" interaction, i.e., situations where someone explicitly tries to find a colleague (Fish et al

1990). Proxy Lady, on the other hand, supports the opportunity to communicate when two people meet.

Further, Hummingbird is a mobile device that aims to support awareness between group members who are in the physical vicinity of each other (Holmquist et al. 1999). Hummingbird seeks to maintain general awareness in (mobile) groups to support spontaneous interaction, while we want to increase the frequency and quality of opportunistic, informal communication.

The Thinking Tag is a wearable, context sensitive nametag (Borovoy et al. 1996). It displays the name of the person wearing it (just like an ordinary nametag), but also tries to indicate how much two persons, standing face-to-face to each other, have in common. The Thinking Tag seeks to augment the social processes of people mingling at conferences (and similar events) by augmenting spontaneous, unanticipated interaction. Accordingly, it is less work and task related than Proxy Lady.

3. Proxy Lady in Practice

The user trials of Proxy Lady include several workshops at four different companies. At one of the companies Proxy Lady was used during several weeks. This company is one of Sweden's major Internet consultancy company, with more than 1000 employees. The office we studied has about 40 employees, including developers, administrators and management. The office was located in one floor, with some subsidiaries at another floor. At the entrance there was a large front desk with two receptionists working during office hours. The rest of the office consists of four corridors that start from the entrance. In the arms there are offices, conference rooms and a coffee room.

3.1 Data Collection and Analysis

Further, four workshops where conducted with personnel from different backgrounds. One group consisted of system administrators at a university, two different groups of groupware consultants and one group of team managers at an IT-consultants agency.

We used a digital video camera to capture the workshop sessions. Five sessions where conducted, including the four groups. The fifth session was conducted after the trial with the users of the ProxyLady system. The sessions resulted in more than six hours of video.

At the site where we made the study, five employees where equipped with Proxy Lady clients. Observations where conducted during approximately 20 hours. After the observations, log files from the systems where analysed to gain more knowledge of the use. The study lasted for about three weeks and was concluded with a workshop, lasting for about two hours. During the observations notes where taken continuously and the workshop was videotaped and transcribed. All observations and workshops where transcribed.

The trial sessions of Proxy Lady with the four groups served the purpose of assessing the concept of Proxy Lady in their working context and getting user feedback on the system to consider in re-design before setting up a proper long-term evaluation in a client organization.

The workshops were based on the pluralistic walkthrough approach (Bias 1994). Pluralistic walkthrough is related to cognitive walkthrough and “jogthrough” (Nielsen and Mack 1994). It advocates an open discussion between designers, usability experts and users, investigating the usability of the steps associated with a task scenario. The user session of the systems administrators explored “helping users,” the groupware consultants “cooperating while working in a project,” and the IT consulting agency “organizational communication.” The final workshop was with the persons that actually used the system for about three weeks.

3.2 Results

The results of the evaluation sessions concern the concept of Proxy Lady and ideas for improvements. Let us start by summarizing the main issues regarding the concept of the system.

3.2.1 Overall Ratings

Both during the workshops and during the evaluation period the task domain that Proxy Lady seeks to support was recognized and considered important. There was also a general agreement that these tasks are important. One of the participants said:

> Thomas: It is a good step to take, it is so darn logical and we know that we will take it.

Further, the following was said about the effectiveness of the system:

> Moulder: This has shown that it is possible; we have come that for now. Sure, it will work.

3.2.2 Privacy

When using location aware computers that communicate the position of a person, discussions on privacy are often raised. The Proxy Lady system is not aware of the location of the user. All it can collect information about is who are in the proximity, which might be a potential problem to a person's privacy or integrity. During the evaluation period no such situations were observed, but during the workshops participants raised issues like what happens if someone if "using the facilities" and another Proxy Lady user passes by. People expressed concerns for the potential misuse of the system. However, they all seemed satisfied with the "invisible mode." Yet, it was important to avoid "lurkers", i.e. users who are always invisible, but still benefit from the system.

Therefore the “invisible mode” actually turns off the whole system, which means that the “invisible” person is not able to see what other users who are in the proximity.

A funny comment was made by one of the systems administrator when he understood the concept of Proxy Lady: “Oh great, then I can be notified of annoying users, and just run the other way or close my door”! Some other participants of the workshop had a discussion whether Proxy Lady actually increased their privacy at work, since they could use it to be prepared of who might enter the office the next second. “A kind of ‘boss-is-coming-alert’”.

3.2.3 Physical Constraints

Proxy Lady would mean “yet another device” for people who use PDAs other than the Cassiopeia. However, users of other PDAs platforms could either migrate to the Cassiopeia platform, or the Proxy Lady system could be implemented on other types of devices. The use of Bluetooth will mean a standardized physical communication media. Therefore, the Proxy Lady system could be implemented on a variety of different systems, including the PalmOS.

When implementing a system like Proxy Lady on a PDA, a possible problem might be that the users would have to carry around the device wherever they go. Our study showed that the users sometimes forget their PDA, meaning that the system does not work – and maybe even signal their presence at places where they are not located.

A Complement to Existing Communication Channels. When describing the Proxy Lady system, some argue that it would be more suitable to just call the person when a topic comes up, rather then to enter the topic in Proxy Lady and wait for the opportunity to come up. However, the reported importance of informal communication even in work related settings (Whittaker et al. 1994, Kraut et al. 1990, Fish et al. 1990) is a firm base for the design of the Proxy Lady system. We do not try to argue that it should replace other channels for

communication: It is a complement to existing channels. During a workshop one of the participants claimed:

> Dick: Since yesterday […]I have been trying to reach a person named John Smith. He does not answer telephone calls, does not answer on voice messages, and does not answer e-mails.
>
> Alice: I know where he his…
>
> Dick: Do you know where he is?
>
> Alice: Mmm [nods] he has been here all day.
>
> […]
>
> Dick: I would have found that perk if we had used one of those (pointing at his ProxyLady device)

This example shows that e-mails and telephone calls sometimes are not enough. If he was notified when passing John (maybe behind a closed door), he would have the opportunity to discuss this important issue. However, in many other situations the other channels of communication are superior.

3.2.4 Event-Driven Work

During one workshop some participants expressed a number of possible problems when using Proxy Lady. One important comment was that Proxy Lady would make them even more "event-driven." With "event-driven" they meant that it would be even harder to plan the working day, since you would be interrupted with suggestions on discussions all the time. This question was handled during the workshop after the evaluation period. One of them said:

> Moulder: Yea, You become more event-driven. It is yet another thing that calls for your attention. In the same way as cellular phones does. If someone calls you have to handle it. In my professional role is it not so bad, the other way around. Often, events lead to positive results. […]so, yes and no depending on who you are. You have to be able to handle that. Turn it off.

This discussion is similar to the contemporary discussions of cellular phones. Many people have expressed concerns that they do not want to be reachable 24 hours per day. The solution that most people have adopted is simple: When it is not suitable to be interrupted by a telephone call, the cellular phone is turned off. This method would, according to the workshop participants, apply to Proxy Lady as well.

Maybe, a system, such as Proxy Lady, would not be suitable for everybody. Like Dick commented, a developer might be more effective without the Proxy Lady, especially when the project deadlines are approaching quickly. On the other hand, previous studies show that even developers rely on informal communication in their professional role (Bergqvist et al. 1999).

3.2.5 Use Problems

Proxy Lady is a prototype and not a final system. Our resources available for development in a research project are limited. This affected the quality of the prototype, which resulted in some problems when using the system.

Proxy Lady was not integrated with other related systems. The organization that used Proxy Lady uses the Microsoft Exchange platform to handle appointments, mail, contacts and tasks. The tasks, or items, in the Proxy Lady system were not integrated with the exchange platform. Some users thought it was problematic, since they sometimes had to enter the same task twice. One user said, “you are missing the ‘glue’ between the systems.”

Our hardware solution on the radio side did not function as well as intended. First, the range was lower on some devices.

Further, since the radio transceivers where in the way for both synchronizing and recharging batteries, the system could not be used when docking the PDA, and vice versa. Further, the radio transceivers were turned off sometimes, due to a bug in the integration between the PDA and the radio.

3.3 Suggestions for Improvements

During the evaluation of the system many suggestions for improvement were discussed. In this section we summarize and discuss some of the most important suggestions.

Positioning. Many users wanted to extend the functionality of the Proxy Lady platform. Today, the application notifies when a person is nearby. However, many situations would benefit if the user knows another person's location. Consider, for instance, the following example:

> [Moulder is in his office] He walks out to the corridor, passes the reception and stops outside Rick's office. Moulder checks his Proxy Lady, but it does not detect that Rick is in the proximity. Rick is not there. Moulder turns around and walks back towards his office.

In this situation it would be good to know whether a person is in the office or not.. Some of the persons in the test-group wanted to know the exact location (e.g. 'in the meeting room'), while some preferred to have a radar view where they can see distance and direction to another person.

Today, Proxy Lady does not support locating people. However, there are other systems that provide this support, e.g. ActiveBadges (Want and Hopper 1992). Since Proxy Lady is designed to support the initiation of opportunistic interaction, locating people is outside the scope of Proxy Lady. On the other hand, a merge of the functionality of system to locate people and Proxy Lady could provide the users with a more complete support for informal communication.

3.3.1 Pre-planned vs. Spontaneous Interaction

The current version of Proxy Lady is based on opportunistic interaction (Fish et al. 1990). That is, a participant must pre-plan a future interaction before a notification can occur. Another type of interaction is spontaneous interaction (Fish et al. 1990). Spontaneous interaction is not pre-planned by either party: It and takes place spontaneously!

Some users wanted Proxy Lady to filter out other type of information based on who are in the proximity. For instance, if two persons that are scheduled for a joint meeting later that day, the user could benefit from being notified about that meeting. The filter mechanism should work automatically: The user should not have to mark the information to be notified. By using these kinds of links between documents and resources, useful information could be able to be presented to the user. This type of support would be possible to implement, even though it is not implemented in the current version of Proxy Lady.

If Proxy Lady would include support for spontaneous interaction, it might lead to an overload of information items that are notified far too often. Therefore, our users in the trial suggested the use of profiles to filter out (possibly) interesting information. The profiles were suggested, either to be static or dynamic using agents.

3.3.2 New Information Items

The current implementation of Proxy Lady only supports two types of 'information items': Those are e-mails transferred from the desktop computer and tasks entered directly into the Proxy Lady client on the PDA. The architecture, however, could easily be extended to support other types of information items. During the workshops several other types of items where discussed.

Quite often, some participants noted, people want to share information on relevant web pages. They often want to discuss the pages, and maybe browse the site together with others. Therefore, they suggested the possibility to transfer a

web page on a browser the Proxy Lady system. On the PDA, it would be possible to see the URL and a brief summary of the actual document (e.g. only the text). The URL should be transferable to the other Proxy Lady users. When the receivers of the URL go back to their office, the URL should be transferred to the bookmark list of the browser on the desktop computer.

During the workshops, there were many suggestions of other types of information items. The groupware consultants, for instance, wanted to associate documents.

3.3.3 Notification of Artifacts

The system administrators argued that a large portion of their work concerns updating workstations and servers. Quite often they do not update a computer until they are nearby. Therefore they suggested the possibility to equip computers with a Proxy Lady identity, which would make it possible to associate program patches to a computer. Other participants suggested that it would be great to get a reminder when they leave the office (or their home) in order to not forget to bring some stuff. The solution would be to equip some places and other resources, such as computers and printers, with radio transceivers. Each transceiver would have an identity that would make it simple to associate items with that resource of place.

3.3.4 Range of Proximity

The relevant range of proximity for a person may be difficult to set to an absolute value. The suitable range seems to depend on the setting, as well as what person that it concerns.

All groups gave us different ranges for a suitable proximity, from 5 meters up to 50-100 meters. The best solution to handle this would be to have a knob where the range could be set. Using the Bluetooth it might be possible to set the range and it might also be possible to analyze the signal strength to determine how far away the source of the signal is. However, that is yet to be proved.

The range in meters is not always a good measurement for proximity between people. A wall might be in the way. Even if two persons might be only 3 meters away from each other, it might take a 100 meters long walk around the wall for them to actually meet.

Finally, one user said that persons who you are nearby all day should have a very short range, maybe 2-5 meters. If a person that is seldom nearby, you might want to get a notification if she is in the same building as you, even if she is 100 meters away. Therefore, it would have been very good to be able to set the range different for different people.

4. Related Work

Some studies have been conducted on the use of related devices. This body of literature involves user trials of most of the systems described in the section on related systems above. All studies we have found, except for the Active Badge study, are conducted in a much shorter period than our study. There are also differences in what the systems seeks to support. Therefore, all the studies are slightly different, but they also share some interesting properties.

Hummingbirds (Holmquist et al. 1999) were designed to support "group awareness." The group awareness that is provided in the system is a list of what other persons in a group who are within a range of 100 meters. User trials in office settings showed that Hummingbirds was a useful tool to collect information on who were in-house and if it would be fruitful to go looking for a person in the group. When using Hummingbirds in "unfamiliar settings" (e.g. a rock festival) the users reported a "feeling of connection." They knew that other persons in the group were nearby, even though there might be no eye contact.

The current implementation of Proxy Lady, on the other hand, has a shorter range (about 20 meters). Therefore it might not function as good as an awareness device to collect

information on what other persons that are in a building or to get a wider "feeling of connection." However, some Bluetooth equipment will have a range of up to 100 meters. Using Bluetooth, Proxy Lady can function in a similar manner, even though the objective of Proxy Lady is to support opportunistic interaction.

The other study of Hummingbird (Weilenmann 2000), discusses the "negotiation of use." When and in what situations should the Hummingbird be used? In the bar? Only at work? Weilenmann stresses that the users of Hummingbird had to negotiate the use since their use was interdependent. Our study only included studies of work. However, when having a piece of technology that relies on how other people are using that technology, it implies that a negotiation of use take place. An example in our study is that users in the group complained when other users did not have their Proxy Lady switched on.

The Active Badges were used in several "real settings" for long periods of time. One study is on how the people experienced the use of the badges (Harper 1995). This study was conducted at the site where the badges were designed. The focus was to investigate why people wear or do not wear the badges. The author argues that there are not only rational reasons why a technology is adopted (or not). Issues, like symbolically values, moral and fear might be just as important. The "act of wearing a badge" was a social act that expressed a wider "meaning" than the rational reasons.

It is not possible to draw similar conclusions with our material. There was only one group that tested out the system. One developer was not allowed to use Proxy Lady, since there was a deadline coming up. He was supposed to finish his code and not run around and talk to people. This, however, is something different from the point taken in the Active Badge study. The discussions on privacy in the Proxy Lady study might be affected by those kinds of issues. The people we studied had a generally positive attitude to new types of technology. However, we held workshops at four other companies. Nobody expressed a very different attitude towards the technology. Rather, the

general conclusion on privacy and other social issues was that there might be some problems, but that development of support, such as Proxy Lady, is positive.

5. Conclusion

Based on the field trials of Proxy Lady reported in this paper, we may draw the following main conclusions:

- The task domain that Proxy Lady seeks to support was recognized and considered important
- Privacy might be an issue. The invisible mode seemed to be a satisfying solution.
- The current implementation had a number of physical constraints that made it used less. Some other use problems included the quality of the hardware.
- The work might be more event-driven, which was considered to be a positive thing for some people but can be a problem for others at times.
- The Proxy Lady should be seen as a complement to existing communication channels and not as a replacement of (e.g.) cellular phones.

The suggestions for improvement include better positioning capabilities to find people, support for other types of informal communication, e.g. spontaneous interaction, as well as new types of information items and notifications of artifacts. Some of the suggestions are supported by other systems, while some others are new. Some of the suggestions will therefore be implemented in future projects.

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Sixth Paper

Desk Panel: A Proximity-Based Information Panel for Locally Mobile Staff

Per Dahlberg and Johan Sanneblad

Abstract

DeskPanel is a proximity-based information panel helping locally mobile people to quickly get an overview of centrally stored information, such as e-mails and tasks. According to user trials, DeskPanel has the potential of being a useful tool for mobile staff. This paper outlines the rationale, design, implementation and user trial of the system.

1. Introduction

In a world of increased mobility, the recent growth of Personal Digital Assistants (PDAs) seems like a step in the right direction. While initially being used exclusively as digital calendars, the potential of these devices seems obvious as manufacturers incorporate applications such as e-mail clients, web browsers and offline document readers. However, these applications suffer from some major drawbacks, including the difficulty to rapidly overview information. For example, in order to check new

messages (email, fax, internet news, etc.) the user has to launch several applications, which is very time consuming. This may not be optimal for stressed people who spend their working day running between meetings.

In this paper, we present one possible solution to this problem, the DeskPanel system. DeskPanel is a proximity-based information panel designed to provide easy overview of selected information to locally mobile staff in organizations. An organization can contain several publicly available panels integrated into the environment, just like whiteboards are used today for note keeping. DeskPanel shows centrally stored information to the person that passes by. Built upon the premise of short-range ad-hoc network technologies such as Bluetooth being built into most devices in the near future, DeskPanel uses the short-range limitations of these technologies to create new types of proximity-based services for its users.

The structure of the paper is as follows: First, we describe the DeskPanel system – its interface, use, and implementation. Some preliminary user trials are presented next, followed by related work. Finally, we present a discussion and concluding remarks.

2. Desk Panel

DeskPanel is a proximity-based information panel, created to increase the accessibility of information in organizations. In this section we will describe the use, architecture and implementation of DeskPanel.

When people are locally mobile (Bellotti and Bly 1996, Bergqvist et al. 1999), they have certain waypoints they use to collect information about their daily schedule. Typical examples include service desks, the local receptionist, coworkers, and of course their own office space. Finding important information can be a matter of being at the right place at the right time, or regularly visiting all places during the day to get updated.

To aid people in accessing their information, we present proximity-based information panels. These are flat-screen monitors integrated in the office environment, either hung to a wall or placed in an office window. When a person comes within the proximity of the screen, it changes context and displays information based on the person's customized profile.

Proximity-based information panels consist of four different components (see figure 1 below): (1) a screen, (2) a small, networked computer system, (3) a radio transceiver, and (4) a portable trigger carried by the people that want to use the system. Triggers are small, portable radio devices that are used to identify a person to the information panel. Since the triggers vary in size, they can be attached to a person's handheld computer, mobile phone or even a key ring.

Using an information panel can be automatic, manual or both depending on the type of trigger being used. Triggers can be manual, automatic or controllable. Examples of triggers are a manual "car alarm" with a button, automatic mobile phone connection through Bluetooth, and a controllable connection ("automatic connection on/off") using a PDA with wireless LAN.

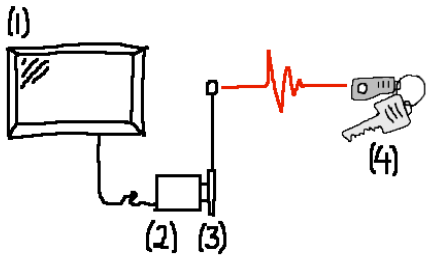

Figure 1. The components of Proximity-Based Information Panels.

2.1 Scenario

The following scenario is used to illustrate the kind of information accessibility DeskPanel seeks to accomplish:

> John arrives late this morning. He quickly rushes up the stairs to his office. He knows the budget meeting began ten

minutes ago, and that he's also been waiting for an email from the local support personnel regarding his broken laptop. After saying hi to the receptionist, John passes by a DeskPanel screen currently showing a movie of an aquarium on the wall.

When John passes by the screen, the PDA in his hand sends an identification code to the DeskPanel. The movie fades away and a picture of John appears (see figure 2). He can read a message from his co-worker Bob that the meeting has been moved to a different location. A quick glance at the headers of incoming emails (also displayed on screen) shows that he has not received an email regarding the laptop yet. John quickly runs to the new meeting location.

When the meeting is finished, John and his colleagues are on their way to lunch. Even though they are discussing an important topic, John gets a chance to take a quick glance at another DeskPanel on their way out to find out that his laptop computer has returned from service.

Figure 2. John, on his way to the meeting

In the above scenario, the DeskPanel is used for three different purposes:

- Reaching mobile people. One of John's co-workers wanted to alert him that the meeting room had changed, but could not reach him.

- Keeping up-to-date with events. John used DeskPanel to automatically poll his mail account for changes.
- Non-interruptive access. John was able to check for new messages while keeping a dialog with one of his co-workers.

We will now describe how the DeskPanel interface is operated and configured from a user's perspective.

2.2 Interfaces and Use

The main interface of DeskPanel consists of a number of "information elements." These are graphical components used to display information to the person that is currently within the proximity of the DeskPanel. Examples of information elements are a picture of a person, a view of unread emails and Intranet news. These three elements are shown in figure 3 below.

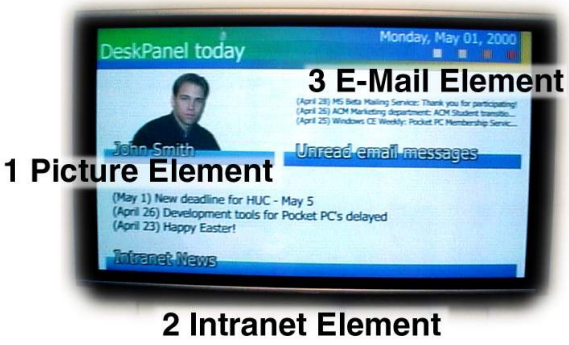

Figure 3. The Desk Panel Interface.

In order to get the DeskPanel to recognize and show individual information for each person, a simple web configuration program was built (as seen in figure 4). Here the user can register his device ID, choose which information elements that should be displayed and alter the screen coordinates of these elements.

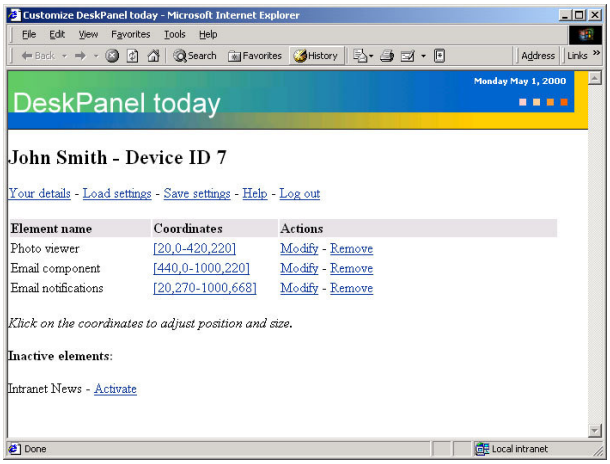

Figure 4. The web-based configuration system

All information elements have their own properties, and each element contains its own customization interface available from the main configuration program (see figure 4 below). Since each element has a unique look and custom properties, configuring the elements require specific instructions that vary depending on their type.

Each information element can in turn contain additional elements. An example of this is the “Photo Viewer” (see figure 5), which lets a person show his picture as an ID on the screen when she passes by. The Photo Viewer element configuration lets the user specify both what “sub-elements” to show (picture, name, and department) and also enables uploading both primary image and alpha channel if available. The “Photo Viewer” is thereby an “information element” that has a number of properties that can be set, including information on what “sub-elements” to show.

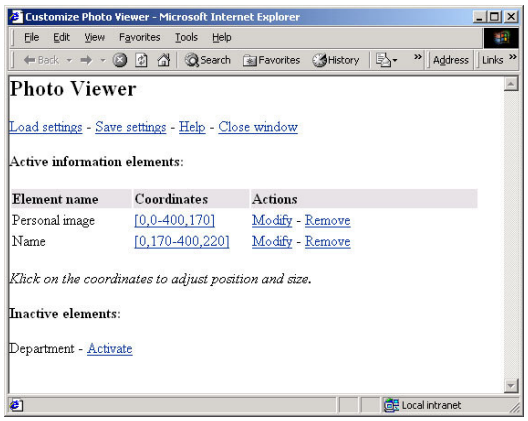

Fig. 5. The Photo Viewer configuration screen.

Once configured, the DeskPanel system requires no further interaction from the user. In order to send notification alerts, such as appointment re-scheduling, a person only has to add the prefix "!!" to the subject title of an email sent to a person. This makes the DeskPanel automatically show the item in a separate information element called the task-list element. The task-list is more visible than the e-mail element (different font style and size). Emails prefixed with "--" automatically becomes invisible.

When DeskPanel is idle, the software controlling the screen is running an animation or an image slideshow to show that it's awaiting user requests. Later, when a person passes by, user identification is sent from the client radio transceiver to the DeskPanel receiver. The system then connects to a central gateway that contains all the necessary user settings and passwords to retrieve the data to be shown. If several users pass by the DeskPanel at the same time, each users data is displayed for a time period of 10 seconds. The necessary passwords to connect to the gateway are protected by encryption.

2.3 Implementation

When implementing DeskPanel we focused on it being interpreted by the user as an "intelligent screen" rather than a complex computer system. Therefore, one of the requirements we made was that the computer system controlling the screen should be so small that it could be hidden away. If an

organization were to implement the DeskPanel on a full-scale basis, the hardware also should be relatively cheap to purchase.

DeskPanel was implemented in Visual C++, which has relatively low demands on hardware. The code base was built and tested on both Windows 2000 and Windows CE, so that DeskPanel could run on a small handheld PC with a built-in VGA controller. Using the handheld alternative, it is possible to pack the system, wireless network connection and radio transceiver in a very small package that actually could be hidden behind the screen itself.

Three information elements, “plug-ins”, were created for the first version of DeskPanel. These were the photo viewer, an email component and a task list. The photo viewer shows a picture of the person that comes by, the email component displays all or unread emails, and the task list displays specially marked emails that should be displayed using a larger text font.

Each DeskPanel system communicates with a central gateway using a custom-built protocol. The gateway maintains connections to all company information, such as calendars, emails, and Intranet news. What is elsewhere referred to as “Information Elements” is really dynamic link libraries (DLL’s), which run both on the gateway and the DeskPanel system. Since both the gateway and the DeskPanels share the same code base, only one copy of each DLL has to be made. This copy then runs on both the gateway and the DeskPanel, but with different functionality (retrieve data / display data). A picture describing the Proximity-Based Information Panel concept integrated with the office gateway is listed below in figure 6.

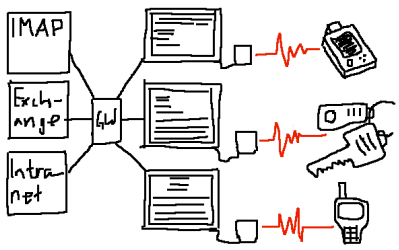

Figure 6. System Components

2.4 Hardware

DeskPanel was built on the premise of Bluetooth being built into every device within the forthcoming year. This would make it possible to use devices such as mobile phones or key rings as triggers. The trigger would then automatically be detected by the DeskPanel system when it comes within the proximity of the radio transceiver (Bluetooth has a range of 10 meters).

However, at the time of writing Bluetooth is not publicly available, so we had to implement our own short-range radio transceivers with similar functionality. The transceivers we built were custom-made short-range radio transceivers that are connected to the side of a handheld computer (Casio Cassiopeia E-105). The transceivers were previously used in a project called Proxy Lady (Dahlberg et al. 2000), and can be seen in figure 7 below.

Figure 7. A Cassiopeia PDA equipped with a trigger

The radio transceiver is controlled by a custom application built for the Cassiopeia, and is using the serial port to get enough current to run. Once every second the transceiver broadcasts a public ID signal, which is captured by the DeskPanel system to identify the user. The range of our radio transceiver was around 10 meters.

Currently, we are using a laptop computer to run the DeskPanel application and a flat screen to display the user interface. The laptop is fitted with the same type of radio transceiver as the PDA.

3. User Experiences

To receive input on DeskPanel we equipped six employees at an international web-consulting firm with radio transceivers that fitted to their current PDAs. Each person had a different role in the organization that ranged from developer to team manager. All participants knew each other before the test period started, and three of them worked in the same project. The company employed more than 1000 persons and the local office hosted around 40 people. The office space was located in one oblong floor, with a reception desk at the center and four corridors starting from the reception desk.

We placed one DeskPanel screen at the reception desk in the center of the office building. The two receptionists were already using emails to notify people about incoming events, which would work directly with the DeskPanel system. The reception desk is a place where people pass by several times per day, either on their way to a conference room or to search for a colleague. DeskPanel was implemented on an ordinary laptop that was hidden behind the reception desk so that only the screen was visible. The information elements used were the photo viewer, e-mail, and the task-list element.

After having used the system for two weeks, we invited the participants and one of the receptionists to a workshop. To capture the session we used a digital video camera. The entire workshop was transcribed into text.

3.1 Results

The comments made by the users during the workshop session concerned their actual use experience with DeskPanel together with ideas for improvement. Most users said that they had used the DeskPanel on a daily basis, which also was confirmed by the system log.

Information Elements. All users agreed that a solution that provides a distributed, non-interactive email overview is important. One user commented that he wanted information

items that also support to-do lists and distributed calendars, which the others agreed on. All participants positively supported the picture information element. One user mentioned that guests who had come to visit him could see his image and name on screen while he was approaching them, which he claimed increased the value of DeskPanel.

Functionality. One problem one user mentioned was the 10-second cycle period. If several users are in the proximity at the same time it takes too long before his information is presented. Another user had his office just a few meters from DeskPanel. Since his office was so close, DeskPanel trigged his personal information while he was sitting in the office. The user did not consider this behavior of the system to be acceptable.

Added value. All PDA users expressed their feelings for DeskPanel in a positive manner. However, the receptionist mentioned that she did not think that DeskPanel provided any kind of support in her own daily work. Instead, she got additional questions regarding the DeskPanel system from visiting users. She said that this was a negative factor in her work. She also mentioned that the receptionists had not used the special “task list” feature to provide notifications on the DeskPanel except for the first day.

New features. One of the things currently not supported by DeskPanel that was mentioned by several users is the ability to physically locate people within the organization. The receptionist mentioned that she was asked this question a lot.

Trigger. One user mentioned that he always carries his mobile phone within the building, but seldom the PDA. It was simply too large and too heavy. Our test equipment with a PDA and an additional radio transceiver was among all users judged out by being too much to carry in daily work. During the trial period, though, they agreed to bring their PDAs with them all the time.

Privacy. No user mentioned any potential privacy issues using DeskPanel to show personal data on a public display. One person mentioned though that he changed his picture size to a smaller format during the beginning of the evaluation period, since he was not comfortable with the old image.

We intend to use these comments when we design the next generation of DeskPanel. Among the things that need improvement is the office integration, with full support for both calendar and tasks. We might also look into location awareness, so that each user via a web interface can specify one or more people for which to show their last known location. This would make it possible to see when a person passed by a certain DeskPanel.

4. Related Work

The use of context as a resource for mobile computing, called context awareness has been previously explored (e.g. Want et al. 1995, Schilit et al. 1994). There are several different types of context that an application can use, e.g. location, temperature and light conditions.

The most commonly used type of context is location. By filtering out information based on the current location, a user only has to be concerned with the information that is relevant for her present position. These kinds of systems are often categorized as location dependent systems. Among this type of systems, we find Shopper's Eye (Fano 1998) and Cyber Guide (Abowd et al. 1997).

The DeskPanel is context-aware, in the sense that it is aware of what users that are nearby. However, DeskPanel is not a location dependent service. Location dependent services typically aim to provide the relevant information at the right place. The DeskPanel, on the other hand, is a ubiquitous effort to provide an overview of relevant information at several places. It does not customize the information depending on location.

Digital whiteboards are computer-driven displays that seek to combine the ease of an ordinary whiteboard with the novel features of a computer-based editing and organizing software. Research in this area ranges from interaction and organizing techniques (e.g. Rekimoto 1998, Pedersen et al. 1993, Gessler 1998), to complex interactive environments that seeks to

change the way we think of office environments today (e.g. Mynatt et al. 1999; Streitz et al. 1999). DeskPanel might be a modest step in this direction.

However, DeskPanel is a non-interactive display that provides centrally stored information (e.g. emails and tasks) in a mobile setting. DeskPanel does not only distribute the same centrally stored information independent of location. It also does so automatically without any interaction requirements from its users.

Digital whiteboard systems have distinct requirements on placement and screen size, and are typically placed in meeting rooms. DeskPanel, on the other hand, should be placed in corridors and other places where the personnel pass by.

Adding DeskPanel functionality to an existing digital whiteboard would be possible, but form factors and location would probably restrict its use. However, adding whiteboard features to DeskPanel using remote manipulation tools (such as those described by Rekimoto 1998) would be possible without sacrificing it's current functionality, just by using an "interactive" information element on screen for input.

Ubiquitous computing (Weiser 1991) is a concept that has gained a lot of interest since its introduction about ten years ago. In the concept of ubiquitous computing information technology is described to fade away in the background of the environment. Interfaces should be available everywhere in the environment, ready for interaction when a person needs it.

5. Discussion

In this section we discuss some emerging issues related to the DeskPanel. The topics include both technical aspects as well as aspects on the use of the system.

5.1 Privacy, awareness and disruption

Broadcasting personal information in an organization is a sensitive matter, which should be taken very carefully. Issues regarding privacy, awareness and disruption in everyday work are matters that have to be taken into account when building public information systems like DeskPanel.

Providing awareness information will always affect privacy, either for the sender or the recipient depending on what type of information is transferred and if the information is shown in public or not. At the same time, the more information being transferred the greater is the risk of privacy threats. Increased awareness may also have the side effect of increased disruption in normal work. The effect awareness has on these two factors has been categorized as “The Dual Tradeoff” by Hudson and Smith (1996).

DeskPanel provides several solutions to keep a high awareness factor, and still respecting both privacy and disruption factors in everyday work. By using manual or controllable (automatic on/off) triggers it is possible to restrict the use of DeskPanel when there are people around. Using these kinds of triggers, DeskPanel also does not have to disrupt ordinary day work since the system can be turned off completely for individual users, and switched on by demand. It is also possible for an e-mail sender to block emails from being displayed on the screen, assuming that she knows how to use the blocking-filter.

Designing with respect to privacy is often easier to overcome by filtering data (e.g. blurring out areas of information). This is a technique commonly used when building shared media spaces. Filtering information in DeskPanel (e.g. blurring the email headers so that they become unreadable) would lose some of the systems usability, but still provide value in that the user gets an awareness of his/her current information stream. This feature is currently not implemented in DeskPanel but would not be hard to realize. The user focus for DeskPanel would then switch from contextual awareness to content overview.

5.2 Trigger Technology

A wide variety of small devices will incorporate Bluetooth when it becomes publicly available. IDC forecasts (IDC Report 2000) that more than 400 million devices will be Bluetooth-enabled by 2004. Many cellular phone manufactures have already announced that they will support Bluetooth, which would make them suitable for triggers for DeskPanel.

RF Tags, or transponders, is a technology that is very small and do not require any batteries. The transponder can be so small that it can be fitted into a sticker. When a transceiver sends out an electrical current, the transponder "wakes up" and sends an ID back to the transceiver. This technology is commonly used for parcel tracking. A user can put a transponder-sticker in her wallet and then forget about it. However, the range seems to be too short for use with DeskPanel, since it today only functions up to 50-100 cm.

Further, the small radio transmitters that are used for car alarms could be used as a pro-active alternative for the DeskPanel. The devices can be constructed to be very small, but need batteries. Hence, it is not possible to transmit an ID constantly, since that would lower the operating time too much. But as a manual trigger it would probably be suitable.

What technology to choose depends on several different aspects. When Bluetooth is a common standard it seems to be a very good solution. On the other hand, there are no Bluetooth devices on the market today. It will probably take several years before everybody's cellular phones are Bluetooth-enabled. The RF solution is very handy, but might have a too short range of operation. The "car-alarm" solution is also very handy, but would have problems with the battery capacity.

5.3 Ubiquitous or Mobile

As mentioned before, ubiquitous computing and mobile computing is very much in contrast to each other. While mobile technology currently is expanding fast, ubiquitous computing has not gained much interest. At least not in the commercial

world. We want to stress a couple of reasons for not leaving the concept of ubiquitous computing.

First, mobile computing is not suitable in all situations. The main strength of mobile computing is that the user can reach information or communicate wherever she is located. Most current implementations of mobile computing require the users full intention. Reading mail on a PDA, for instance, is very difficult when walking in a corridor. One of the few solutions that do not require full attention is the cellular phone.

Even though the research in mobile computing is developing quickly there seems to be room for other concepts. Such concepts should be better on handling the problem that a mobile person often have to focus on other things than IT-use. Therefore, there might be a place for ubiquitous computing.

One disadvantage with ubiquitous computing is that it often requires a huge infrastructure at all places in which a user might be located. Large displays should be mounted on the walls, sensors should be installed and so forth. This infrastructure will become very costly if efforts are being put to implement that at all places where a user might be located. Therefore, our efforts are put into office environments. The two main advantages with these environments are (1) that employees tend to spend a large portion of their time at the office where they work and (2) companies can invest more easily in IT than private consumers can.

One reason for the lack of success for ubiquitous computing might be that most solutions have been fairly expensive. Flat displays, sensors and other types of technology have not been available or been far too expensive to use in most (real) settings. As it seems, the development is now coming to a point where it will be possible to implement ubiquitous computing-inspired systems rather cheaply. The DeskPanel system, for instance, does not have to cost more than a standard PC. The triggers we use are indeed too large and still too expensive, but as other technologies emerge (see 6.2) the triggers will be very cheap as well.

Therefore, we want to argue that ubiquitous computing has a place, not only in research, but also in the commercial

world. Some shortcomings with the technology (e.g. price, availability) seem to disappear as technology develops, while some other problems resists. Ubiquitous computing has some advantages where mobile computing does not help much, and vice versa.

6. Conclusion

In this paper we have presented DeskPanel, which is a proximity-based information panel. According to preliminary user feedback, proximity based information panels seem to a useful means to provide mobile office workers with overview of information.

Suggestions for future work include a full evaluation at several sites, which is required to provide more information on its use in the "real world". New triggers need to be investigated, and the functionality of the system can be extended according to the feedback we received from user experiences.

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