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Designing for Local Mobility

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Licentiate Thesis

Abstract

This thesis investigates the characteristics of *local mobility* from a CSCW perspective using ethnographically informed workplace studies and presents a framework for designing IT support. In this thesis local mobility is defined as a work related situation where workers move within a specified physical area while performing their tasks. The research is presented in an introductory chapter and four research papers. The overall research question is: *what are the characteristics of local mobility and how can we design IT support for it?*

The main contributions are a *set of characteristics* of local mobility and a *framework for design* composed of a set of design dimensions. The identified characteristics are *co-ordination* (managing interdependent tasks), *exceptions management* (handling situations not covered by co-ordination tools), *problem solving* (the need to solve work related problems) and *information sharing* (sharing information perceived as relevant for others). The *design dimensions* are *relevance* (how important a task is in relation to the overall work performed), *dependence* (whether a task is carried out autonomously or collaboratively) and *reach* (the type of interaction workers engage in to accomplish a task, either local between co-located persons or remote when interacting with off-site persons).

Keywords	**Language**
CSCW, Local Mobility, Ethnography, Workplace Studies, Co-ordination, Design	English
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Preface

This thesis is a collection of four research papers and is the result of a research effort that began in July 1998. The main topic is local mobility, i.e. how people move about at their workplace. This has proved to be an important facet of work and merits further attention in the research arena as well as the commercial world. This thesis presents a set of characteristics describing local mobility as well as a framework of design dimensions for moving from workplace studies to design. Therefore, the results should prove interesting for both researchers and developers.

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Jens Bergqvist, Göteborg, November 2002

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1. Introduction and Overview

With the emergence of truly mobile computing and communication tools such as handheld computers and mobile telephones significant processing and communication power is now available in use situations where earlier there was none. The focus of this thesis is one such class of new use situations, namely *local mobility* (see e.g. Bellotti and Bly (1996) and Luff and Heath (1998)).

Local mobility is movement within a specified physical area, such as an office, and as it is a rather mundane, everyday phenomenon, it does not immediately reveal itself or capture ones imagination. Examples would include when you are trying to answer a question you received by email and you walk over to a colleague's desk to get her take on the issue or when you cross the room to get an item you need to fulfil a customer order. Several studies, e.g. Bellotti and Bly (1996), Ljungberg (1997) and Luff and Heath (1998), have so far identified and investigated local mobility but as it seems to be an important feature in the work place it merits further study. In the commercial arena mobile systems are being developed with little support from methods adapted for the specific characteristics of mobile use situations. The research presented in this thesis offers insights regarding the causes for local mobility and introduces a

framework for taking the step from workplace studies to design of IT support for locally mobile work.

The scope of the thesis is limited to the workplace; therefore the definition of local mobility used throughout the text is *a work related situation where workers move within a specified physical area while performing their tasks*.

The research question is as follows: *What are the characteristics of local mobility and how can we design IT support for it?*

1.1 Thesis Overview

This introductory chapter is followed by four research papers listed and summarized here.

The first paper presents a field study performed at a packaging department of a large electronics manufacturer as well as design suggestions for IT-enabling the locally mobile workers and improving the throughput of the department. The analysis of the field data draws heavily on co-ordination theory and a cultivation approach. Publication details: *Bergqvist, J. and Dahlberg, P. (1999). Scalability through Cultivation: Using Co-ordination Theory in Design. Scandinavian Journal of Information Systems, Vol 11, pp. 137-156, 1999.*

The second paper presents a field study carried out in a software development office, part of a city's IT department. The main contribution is the concept of *mobile meetings*, which is a form of work place interaction that carries characteristics of conventional meetings as well as informal interaction but is in fact a third form of interaction. Some important characteristics of mobile meetings are then presented. The Dynamic To Do List, a design for supporting mobile meetings is the second contribution of the paper. Publication details: *Bergqvist, J., Dahlberg, P., Kristoffersen, S. and Ljungberg, F. (1999). Moving Out of the Meeting Room: Exploring support for mobile meetings. In Proceedings of the Sixth European Conference on Computer-Supported Co-operative Work, pp. 81-98, 11-16 September 1999, Copenhagen, Denmark.*

The third paper takes a critical look at the possible negative effects of deploying the design from paper two. Special focus is afforded to the issues of integrity and privacy. The conclusion is that if utilized with these concerns in mind the benefits of the system outweigh the drawbacks. Publication details: *Bergqvist, J. and Dahlberg, P. (1999). Considering the Social Aspects of IT Support for Mobile Meetings. In Proceedings of the Fifth Americas Conference on Information Systems, pp. 710-712, 1999, Milwaukee, WI, USA.*

The fourth and final paper re-examines the field study presented in the second paper and reinterpret the data from a remote interaction perspective. The paper discusses how mobile meetings are affected by mobile phone calls and offers a design proposal for how mobile phones can be differently designed to better accommodate locally mobile workers. Publication details: *Bergqvist, J. (2000). ComCenter: Supporting Mobile Computer-Mediated Communication. In Proceedings of IRIS 23, Vol II, pp. 1373-1384, 2000, Uddevalla, Sweden.*

2. Theoretical Background

The research field of this thesis is Computer Supported Co-operative Work (CSCW), which takes an interdisciplinary approach to understanding and designing different ways of using information technology to support co-operative work. CSCW is a very broad research field. For an overview, see for instance Bannon (1993).

The first CSCW concept underpinning the research presented here is *mobility,* which has been the overall guide to the subject of research. The goal has been to better understand a certain aspect of mobility (*local mobility*) for the express purpose of supporting design of mobile systems. It is therefore of considerable importance to have a clear grasp of what others have done in the general field of mobility.

The second concept used is *co-ordination theory*, and in particular the notion of *co-ordination mechanisms*. It is argued here

that the use of co-ordination theory may be of significant value when analysing field data from a study of a locally mobile work setting.

The third important concept used in this research is *cultivation*. During the field studies it became clear that the major part of the work carried out functioned satisfactorily. Only a few issues needed to be changed in order to make the work as a whole function better. Cultivation was therefore chosen as the guiding principle for design work as it emphasizes the need for change yet argues for a conservative attitude. This corresponds well to the researcher's perspective on change.

The research is based on workplace studies, which is a common and well established practice within in the CSCW field. See Plowman et al. (1995) for an overview. In this thesis the workplace studies take the form of field studies inspired by ethnographical methods.

2.1 Mobility

A majority of the research on mobility can be characterised as either technology driven design or descriptive empirical studies. Examples of both categories are presented below.

Technology driven research efforts tend to take a technological innovation as a starting point and investigate the potential uses for that piece of technology. Some examples relevant for local mobility are Cyberguide (Abowd et al., 1997; Long et al., 1996), Thinking Tags (Borovoy et al., 1996) and the Active Badge System (Harter and Hopper, 1994; Want et al., 1992). These systems are intended for use within a limited area and depend on positioning to operate. Short descriptions follow.

The Cyberguide is a family of prototypes, developed at Georgia Tech, for exploring the use of location for guiding people in a local setting. Use scenarios include guiding visitors to the research department, where the Cyberguide displays different information depending on the user's location.

The Thinking Tag is a small badge used to initiate communication among co-located people, and was developed within

the Things That Think project at MIT Media Labs. An IR-transceiver in the badge is constantly looking for other badges to communicate with. If a communication link is established it indicates that the user is facing another person wearing a Thinking Tag by turning on an LED. By sending and matching manually input personal preferences of the users more LEDs light up if the two persons have anything in common. This is intended to facilitate initiating conversations during conferences or similar events.

The Active Badge System, developed at the Olivetti Research Center in Cambridge, was intended to allow a small "name badge" to transmit the location of personnel and equipment to a central system via stationary transmitters installed in walls and computers at the site. Use scenarios include routing telephone calls to an extension near the user.

One should also note the ongoing discussion between the three design approaches ubiquitous computing (Weiser, 1991), wearable computers (e.g. Starner et al., 1997) and information appliances (Norman, 1998). All three argues that computers will "disappear" and become less noticeable but suggests different ways of accomplishing it. Ubiquitous computing proposes that computers should be embedded in our environment, wearable computers attempts to merge computers with clothes and similar and information appliances are task specific tools with embedded computational capability.

Empirical descriptions of mobility often stem from studies where researchers have come across mobility while studying some other issue, i.e. they mainly treat mobility as a factor affecting their main topic. Examples of such topics include informal workplace communication (Whittaker et al., 1994), the effects of video technology in banking (Kristoffersen and Rodden, 1996) and the practice of photocopier technicians (Orr, 1991). Recently, attempts have been made to focus on mobility and build frameworks for classifying and understanding it, for instance Luff and Heath (1998) and Kristoffersen and Ljungberg (1998).

Luff and Heath analyses three empirical studies from the point of view of mobility and construct three different categories, remote mobility, local mobility and micro mobility. Remote mobility

concerns persons who move in and between different sites and need access to information and colleagues, local mobility can be used to describe how people move around within a specific site and micro mobility has more to do with how artefacts can be mobilised and used for collaborative tasks.

Kristoffersen and Ljungberg make a different classification when they claim that mobility can be divided into travelling, visiting and wandering. Travelling is when a person attempts to use IT in a vehicle, visiting is where a person uses IT on several different sites and wandering is using IT while walking. As opposed to those of Luff and Heath these categories take into account how different modes of movement affect the use of mobile technology.

2.2 Co-ordination and Co-ordination Mechanisms

Coordination is a central issue in the organization of people and tasks (Mintzberg, 1983; Thompson, 1967). It is therefore a central issue in CSCW (e.g., Schmidt and Simone, 1996; Malone and Crowston, 1994) and the phenomenon is comprehensively investigated in the literature.

One definition of co-ordination is "…managing dependencies between activities" (Malone and Crowston, 1994), 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 and Bannon, 1992; Carstensen and Sørensen, 1996) the resources needed to co-ordinate the work increases when the work setting grows.

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.

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, respectively. In a

work setting the workers manipulate, control and monitor objects according to certain rules, 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.

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 articulate 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.

Dix and Beale (1996) introduce a framework for CSCW 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 when information is mediated through an object e.g. a paper in an in-tray signals the initiation of a different action than the same paper placed in an out-tray.

2.3 Cultivation

This thesis presents results which introduce changes to the studied organisations. *Cultivation* has been adopted as the guiding principle for how the researcher relates to change. The cultivation approach tells us not to change, and thereby upset, an organisation more than what is necessary to accomplish the task at hand (Dahlbom and Mathiassen, 1993). This differs from a construction approach in that construction assumes that a new well functioning organisation can be designed and implemented from scratch with little need for knowledge of the current organization. Business Process Reengineering (Hammer, 1990) is a typical example of the construction approach.

The cultivation approach states that only such areas that function poorly or do not match the envisioned organization should

be changed. This will enable well functioning parts to continue to develop on their own, while unsatisfactory parts are addressed. In fact, it mostly resembles the way a gardener trims a tree to make it grow on its own but in a desired direction. Contrary to construction this requires studies of the actual work setting which is to be changed. There are complex interactions which must be well understood in order to understand which areas should be addressed and in what order. This makes it natural to focus on distinguishing between different activities and examine the interface between them. This is further explored in the first paper, where it is also established that it may be fruitful to support these interfaces with new technology but leave the actual activities to evolve on their own.

3. Research Approach and Method

The Informatics research discipline is concerned with a wide range of areas related to information technology, such as work practices, interface design, education, mobility and knowledge management to name but a few (see e.g. Dahlbom (1996) and Dahlbom and Ljungberg (1998)). The common theme is that it is all about technology *in use*, investigating and changing the *relationship* between people and computers and other phenomena. In this thesis the "other phenomena" are local mobility and interaction between people in the work place.

The research presented in this thesis can be positioned as workplace studies for the express purpose of understanding the work practice well enough to generate ideas for informing design of IT artefacts improving the work practice in question. The overall research process used is common in the Informatics field and can be broken down into three phases: field work, design and evaluation. The included papers focus on empirical field studies and design proposals rather than implementation and thorough evaluations.

3.1 Field Work

In order to gain a good understanding of the research sites, ethnographically informed field studies have been performed. Ethnography is valuable to Informatics researchers as a set of methods for gaining knowledge about work practices in an organisation. Examples include Bellotti and Bly (1996), Button and Sharrock (1997), Button and Harper (1996), Bowers et al. (1995) and Hughes et al. (1994).

However, using conventional ethnographic methods is a lengthy process as ethnographers tend to do their field studies over a period of years. Researchers in the Informatics field do not require the same deep general understanding, since the researcher is not so much looking at whole cultures as on specific work practices in organisations (Hughes et al., 1994). A period of a few weeks or months is usually a sufficient time frame for conducting field studies for informing IT-design. In order to better suit the needs of Informatics research, a less rigorous and time consuming form of field studies has been developed; ”Quick-and-Dirty Ethnography” (Q&D) (Hughes et al., 1994). Q&D is a short, focused field study, normally conducted over a period of 2-4 weeks. The study is driven by the goal of gaining knowledge about phenomena relevant for design; i.e. it is design driven. Further more Hughes et al. maintain that the Q&D study should be started with a design goal in mind; e.g. improve efficiency or develop new software. Methods commonly used in Q&D are observations and interviews. More on these methods can be found in, for instance, Hammersley and Atkinson (1993).

The research presented here is based on two separate field studies. In each study workers were observed for approximately 70 hours over a period of several weeks. Notes were taken continuously during the observations and were complemented with informal interviews for deeper understanding of specific issues.

The first study was conducted at a packaging department part of a modern manufacturing site for advanced communication equipment. The total number of employees at the manufacturing site was approaching 1400 and at the time about 24 persons worked

at the department in focus. The personnel worked in two shifts, sometimes even three shifts, including weekend shifts during workload peeks.

The second study took place at a department in an IT company owned by the local government of Göteborg, the second largest city in Sweden. The department had about 25 employees, mainly working with Lotus Notes development, deployment, administration and support. All of the employees were engaged in highly qualified tasks in an office environment.

3.2 Design

The data collected during the field studies was analysed to arrive at interesting categories of issues to investigate further. In parallel to this effort technology studies took place in order to inspire designs appropriate for the issues from the field studies.

However, moving from field studies to design is a problematic step as the data gained from the studies must be interpreted and transformed into a more rigid form to serve as design specifications for software development. Many papers frequently referenced in the CSCW literature that combine field studies and design suggestions leave out this intermediate step. Examples of this include Hughes et al. (1992) and Bellotti and Bly (1996). The same problem is also highlighted in Plowman et al. (1995), an extensive review of CSCW papers featuring workplace studies.

Because of this lack of methods for design work, one major issue in this thesis is to re-examine the field studies and design proposals in the included papers and initiate the creation of a framework of relevant design dimensions for making explicit the move from field study to design.

3.3 Evaluation

In cases where evaluation has been performed it has been carried out in the form of small workshops where the design suggestions

were presented and the participants expressed their opinions in both verbal and written form. A major portion of the work presented here is empirical in nature and relies heavily on the field data.

4. Results and Discussion

Designing successful IT support for a work practice that comprises local mobility requires the designer to be familiar with the general concept of local mobility as well as the practices of the work place. Re-examining the field studies in papers one and two from a local mobility perspective sheds light on the *characteristics of local mobility*, i.e. the reasons workers have for becoming locally mobile.

4.1 Local Mobility Characteristics

While re-examining the field study data a set of characteristics of local mobility were found by identifying locally mobile activities and categorising them according to what caused the workers to move. Four main characteristics were identified: co-ordination, managing exceptions, problem solving and information sharing. Below they will be explained in more detail and examples of activities for each characteristic will be given.

4.1.1 Co-ordination

In the two field studies, local mobility is important to workers in order for them to co-ordinate their individual, yet interdependent tasks, as well as secure timely access to shared resources.

In the packaging department several artefacts have been introduced to help co-ordinate the work process. That is, their purpose is to co-ordinate the efforts of the participating workers. Since these artefacts are paper-based, such as a work order, and in some cases fixed, e.g. boards that display work load overviews, the workers must move around to make use of them. Another example of

co-ordination taken from the IT department study is when co-workers check in on each other when their tasks are interdependent. The need for coordination is obvious in the case of managing access to shared resources such as conference rooms, printers or heavy machinery.

4.1.2 Exceptions Management

When a specific co-ordination mechanism is missing, malfunctioning or insufficient to support the task at hand, other means must be used. Typically the worker must make some extra effort to do this and it usually involves walking to some other place on the premises. At the packaging department exceptions management was observed at several times, for instance when a work order did not specify where an item was located (or specified the wrong location) and the worker was forced to search for it, or when the worker needed an item from a storage area that was not indexed and had to find a colleague to ask about its location. Similar situations were also observed at the IT department, e.g. when the servers had crashed and the person responsible for operating the servers walked through the office in order to inform as many persons as possible of the cause of the problems they were experiencing.

4.1.3 Problem Solving

Problem solving is not to manage exceptions but to address issues that arise when performing complex everyday tasks. Examples of this from the IT department include getting feedback on a formulation in a document, finding the right person to refer a caller to and asking a colleague about a certain feature in the programming environment. Similar activities were seen in the packaging department as well. A characteristic trait of this kind of problem solving is that it usually pertains to the immediate situation.

4.1.4 Information Sharing

Another characteristic of local mobility identified is the constant need to inform colleagues of how the current situation is developing, a phenomenon described in the second paper with the term *briefing*. This is where a person seeks out another for the express purpose of informing him about an issue perceived as relevant for that person. In the packaging department study the co-ordination needs are very explicit and closely tied to the activity and situation at hand. In the IT department study on the other hand this relationship is not necessarily the dominating one, which also distinguishes it from problem solving. Rather, briefing often involves more general information that the bearer of the information feels that the other person can have use of in the future, i.e. things that are "good to know". An example of this is when an office worker walks over to a colleague to inform her about changes to a schedule for the next week.

4.1.5 Discussing the Characteristics

The set of characteristics described above is not intended to be complete, but comprises the characteristics that were most apparent in the two field studies. More studies are needed to investigate this further. The relevance of the identified characteristics set is supported by the very different natures of the research sites.

It is noteworthy that when applying the characteristics to the field studies examples of all four characteristics can readily be found, but they carry different weight in each study. At the more formal site in the first study a majority of identified issues concerned co-ordination as opposed to the less formal second site where problem solving and information sharing were the major concerns. The difference in focus has implications for design, which is further discussed in the next section.

The *mobile meetings* concept introduced in the second paper is related to the local mobility characteristics as it is a tool for dealing with primarily information sharing although it is also used for problem solving, co-ordination and exceptions management

purposes. Some key features of mobile meetings are summarized here.

Mobile meetings are different from meetings previously discussed in the literature and supported by CSCW systems 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. Four important properties of mobile meetings are introduced, each of which has design implications within the CSCW field:

- 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.

- 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 applications do not make switching between threads more difficult.

- Mobile meetings serve as important ways for people to brief each other about past and future events. Thus it is a valuable tool for dealing with information sharing. Support for briefing could be calm and ubiquitous devices equipped with features for replication and browsing of information.

- 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 (Luff and Heath, 1998).

More on mobile meetings can be found in the second paper and the concept is further explored in Wiberg (2001).

With regards to the first characteristic (co-ordination), it has been argued that it is difficult to make the distinctions used in co-ordination theory in the real world (Heath and Luff, 1992; Rouncefield et al., 1994), as it can be cumbersome to understand what objects are within the field-of-work, if tasks and actions are articulation work or cooperative work, to mention but a few problems.

As described in the first paper the researchers found that co-ordination theory and in particular the notion of co-ordination mechanisms could indeed be used to analyse field data from studies of locally mobile work. One reason for this may be that the work practice studied was highly formalised making co-ordination theory applicable. The distinction between co-operative work and articulation work was valuable as the researchers were able to better understand the complex work practice with its constant need for co-ordinating activities. Using the co-ordination mechanisms concept facilitated the investigation of the interfaces and interrelationships between different activities. Thus, it appears that using co-ordination theory can help identify critical issues when analysing and designing IT support for locally mobile work.

4.2 Local Mobility Design Dimensions

Using the characteristics of local mobility presented above, relevant problematic issues (or tasks) in a locally mobile work setting can be identified. Then follows the question of how the problems can be addressed by systems design. In this section a preliminary framework for facilitating the step from issue identification to design proposal is suggested. In other words, it is intended to support the explicit making of the problematic move from field study to design as discussed in the method section. The framework consists of three important design dimensions that should be investigated for each identified task; *relevance*, *dependence* and *reach*. A design dimension is a scale upon which an observed characteristic can be plotted. This particular set of design dimensions is an attempt to construct an early framework for determining what aspects of a locally mobile

task are important when designing supporting IT solutions. It draws heavily on the experiences from the field studies and design work underlying the research presented in this thesis.

4.2.1 Relevance

The relevance design dimension concerns how a task relates to the overall work process. The design dimension ranges from essential to peripheral. If a task is essential it is an integral component of the productive work carried out. If a task is peripheral it can be considered an obstacle that workers must be overcome in order to carry out essential tasks. The researcher must be well acquainted with the work place and its practices in order to make this judgement. An important factor to take into account is that it is more likely that a new system will be adopted and successfully used if it is aligned with the workers perception of their work (see e.g. Ehn, 1988). Thus, it is essential that the researcher grasps the workers general attitude towards their tasks. How they perceive their work.

Examples of this design dimension at the packaging department include the task of filling a box, which is considered essential and searching for components, which is considered peripheral. Another example observed in both studies is that searching for other persons is often both time-consuming and frustrating.

The relevance design dimension has implications for what the strategy for addressing the task should be. If the task is essential the design should be to support the execution of the task. In the case of a peripheral task the strategy should be to eliminate or at least reduce the effort needed to execute the task.

4.2.2 Dependence

This design dimension describes the degree to which one workers task is dependent on the tasks of others. If a worker only needs to co-ordinate with another worker at the beginning and end of a task, the task can be considered autonomous. If the worker must be

constantly aware of the actions of another worker the task is considered collaborative. An example of an autonomous task is collecting the packages needed to assemble a shipment in the packaging department and a collaborative task can be exemplified by briefings in the IT department where the initiating party must not only be aware of the location of the intended recipient but also of her current situation so that the briefing is not unnecessary intrusive.

The dependence design dimension has implications for what type of applications can best support the task. In the case of an autonomous task a single user system (e.g. database access systems) may suffice while a collaborative task may require a multiple user system where other users are represented (e.g. instant messaging systems).

4.2.3 Reach

The reach design dimension describes the type of interaction workers engage in to accomplish a task. If they are co-located the interaction is considered local and if they are not the interaction is considered remote. Examples from the field studies include the local interaction needed for the IT department personnel to discuss a contract and the remote interaction needed for the packaging department personnel to know the delivery status of antennas, which are assembled at a different site.

The reach design dimension has implications for how the interaction between workers takes place in relation to the system. In the case of co-located interaction the workers are likely to communicate face-to-face and use a single computing device together, whereas a system for remote interaction may need to mediate communication between workers using different devices.

4.2.4 Applying the Design Dimensions

The possible uses of design dimensions will be exemplified below by showing how they relate to three design proposals presented in the

papers, the packaging department proposal, the Dynamic To Do List and the ComCenter.

In the highly structured type of work performed at the packaging department the local mobility characteristic co-ordination appeared to be the dominating factor for improving efficiency. The tasks involved in the actual packaging process were perceived as essential tasks while the added tasks of explicit face-to-face communication for co-ordination purposes were considered peripheral and even frustrating to the workers. In accordance with the relevance design dimension the overall strategy for IT support design was to support the packaging tasks and extensively reduce the need for explicit co-ordination tasks.

Applying the dependence design dimension to the data gathered at the packaging department yields that the overall work performed is mainly autonomous in nature but frequent collaboration in the form of face-to-face communication is forced on the workers by such factors as poorly working co-ordination mechanisms and frequent breakdowns. This frustrates the workers as well as slows down the production rate. By computerizing the current tools for co-ordination and information sharing, making them more efficient, IT is used to reduce the need for explicit face-to-face communication and strengthened the perceived autonomous nature of the work.

From a reach design dimension perspective it is clear that the majority of workers can be considered co-located and that most of the needed interaction is most efficiently carried out face-to-face. Therefore the systems were not required to mediate communication. In general the designs focused on the local setting, with only one exception, integration with external sites.

Focus: Co-ordination tasks		
Design Dimension	**Value**	**Implication**
Relevance	Peripheral	Reduce
Dependence	Autonomous	Single user system
Reach	Local (mainly)	No mediation of communication

Table 1: Package Department Overview

The design concepts derived from the IT department study are different in nature, as the key local mobility characteristics appeared to be information sharing and problem solving rather than co-ordination. The Dynamic To Do List (second and third papers) and the ComCenter (fourth paper) designs are intended to support interaction, as interaction is essential (the relevance design dimension) for accomplishing such tasks since they are highly collaborative (the dependence design dimension) in nature.

The two designs differ in the reach design dimension. The Dynamic To Do List is an attempt to facilitate spontaneous interaction between co-located workers by prioritizing to do items according to what persons are nearby, while the ComCenter presents a new approach to remote mobile communication for locally mobile workers. Both designs were originally derived from the notion of mobile meetings summarized above.

Focus: Information sharing and problem solving tasks		
Design Dimension	**Value**	**Implication**
Relevance	Essential	Support
Dependence	Collaborative	Multiple user system
Reach	Local	No mediation of communication

Table 2: IT Department Overview I (Dynamic To Do List)

Focus: Information Sharing and Problem Solving tasks		
Design Dimension	**Value**	**Implication**
Relevance	Essential	Support
Dependence	Collaborative	Multiple user system
Reach	Remote	Mediate communication

Table 3: IT Department Overview II (ComCenter)

5. Conclusion

The research question posed in the introduction asked: *what are the characteristics of local mobility and how can we design IT support for it*? The research presented here leads to the conclusion that key characteristics of locally mobile work are:

- *Co-ordination:* workers become locally mobile to manage interdependent tasks.
- *Exceptions management:* workers become locally mobile in order to handle arising situations that are not covered by their co-ordination tools.
- *Problem solving:* workers become locally mobile because they need to solve work related problems.
- *Information sharing:* workers become locally mobile to share information perceived as relevant for others.

In answer to the second part of the research question, IT support can be designed by considering relevant *design dimensions*. The design dimensions suggested for analysing locally mobile work are:

- *Relevance:* how important a task is in relation to the overall work performed.
- *Dependence:* whether a task is carried out autonomously or collaboratively.
- *Reach:* the type of interaction workers engage in to accomplish a task, either local between co-located persons or remote when interacting with off-site persons.

The local mobility characteristics are relevant for analysing field data and identify tasks which should be addressed in systems design. Applying the design dimensions to the identified tasks yields information as to what type of service should be designed.

The research presented in this thesis has also generated results in the commercial arena. The packaging department has

implemented the design proposal with only minor modifications concerning what technology to use, and ComCenter related research and development has continued in the Swedish software company Mobeon AB, resulting in the commercially available mPIM product series.

6. References

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First Paper[1]

Scalability through Cultivation
Using Co-ordination Theory in Design

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.

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[1] Bergqvist, J. and Dahlberg, P. (1999). Scalability through Cultivation: Using Co-ordination Theory in Design. *Scandinavian Journal of Information Systems*, Vol 11, pp. 137-156, 1999.

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.

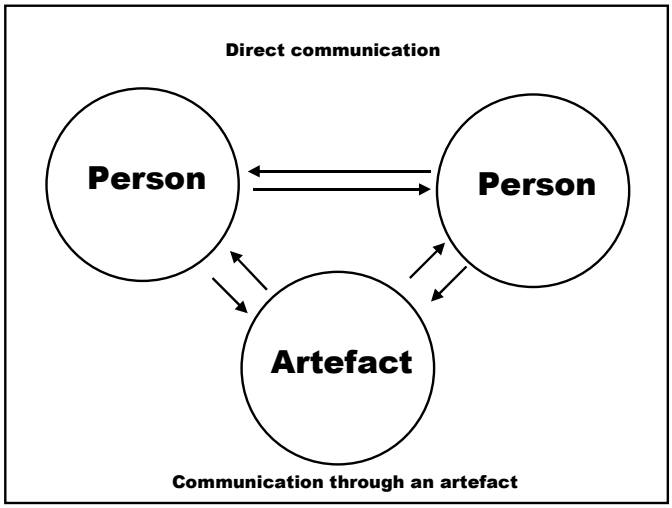

Figure 1: The Dix and Beale framework for CSCW

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.

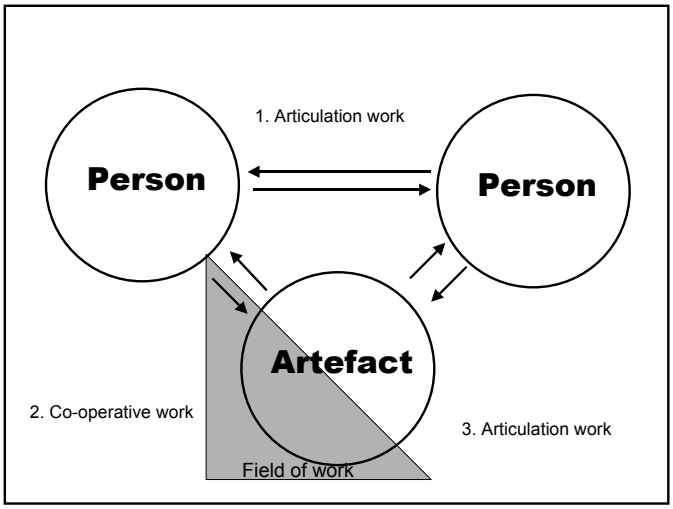

Figure 2: Extended framework for CSCW to understand Co-ordination mechanisms

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 the section titled "A Work Order's Journey".

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.

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Second Paper[2]

Moving Out of the Meeting Room
Exploring support for mobile meetings

"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.

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[2] Bergqvist, J., Dahlberg, P., Kristoffersen, S. and Ljungberg, F. (1999). Moving Out of the Meeting Room: Exploring support for mobile meetings. In *Proceedings of the Sixth European Conference on Computer-Supported Co-operative Work*, pp. 81-98, 11-16 September 1999, Copenhagen, Denmark.

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.[3] 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

[3] See for example the conference on "Cooperative Buildings" (Streitz et al. 1998) and the panel on "Roomware for cooperative buildings" at the CSCW'98 conference.

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[4]) 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.

[4] The names of the people investigated have been changed for anonymity.

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[5] 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[6] 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

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[5] The name of the software package has been changed for anonymity.

[6] The name of the software package has been changed for anonymity.

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.[7] 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.

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[7] As Boden (Boden 1994, p. 87) puts it: "… participation by particular organisational members is expected and accountable."

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.[8] 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.

[8] Streitz and associates at GMD early articulated the need to integrate "traditional" support for face-to-face interaction with other types of meetings (same time other place, different time same place, different time different place). These ideas have been explored in, among others, the DOLPHIN project (e.g., Streitz *et al.* 1994).

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.

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Third Paper[9]

Considering the Social Aspects of IT Support for Mobile Meetings

Abstract[10]

This paper re-examines the Dynamic To Do List, a design for supporting mobile meetings. Mobile meetings are ad-hoc, yet work related, meetings that seem to play an important role in day-to-day business. The possible social effects of introducing the design to a workplace are discussed from three perspectives. The perspectives considered most important are *awareness vs. integrity* (the design may cause some intrusion on the workers' integrity but most likely no more than what is acceptable), *responsibility vs. accountability* (the design may make verbal commitments more explicit and visible) and *social negotiation vs. automated negotiation* (initiating mobile meetings is a complex activity that is best left to social protocols). The overall conclusion is that it is likely that the design is acceptable on these points, but more studies are needed to firmly ascertain this.

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[9] Bergqvist, J. and Dahlberg, P. (1999). Considering the Social Aspects of IT Support for Mobile Meetings. In *Proceedings of the Fifth Americas Conference on Information Systems*, pp. 710-712, 1999, Milwaukee, WI, USA.

[10] This abstract was not present in the published paper.

1. Introduction

One aspect of mobility is local mobility (Belotti & Bly 1996). This less obvious and flamboyant form of mobility concerns how people move within a given area such as their work place. One common place where local mobility would appear is in the office. Office work has changed over the years from strictly individual work where interpersonal communication was perceived of as a distraction to be avoided or even punished to a climate where close co-operation and frequent communication are key factors for achieving success (Ljungberg 1997, pp. 1). In such a setting it is logical to support communication to as great an extent as possible. However, most IT support is stationary, tied to the desktop, making it unsuitable for supporting co-operation and communication between locally mobile people. Now, we can see an emerging trend in mobile technology, which would make such support feasible. But with new technology and new use situations come new problems and limitations, as well as new possibilities. It is obvious that the support needed when on the move differs from the support needed when sitting at a desk (Kristoffersen and Ljungberg, 1998). In order to investigate this we conducted an empirical field study of personnel engaged in knowledge work in a traditional office setting, as reported in "Walking away from the Meeting room: Exploring support for mobile meetings" (Bergqvist et al, 1999). We briefly summarize the concept of mobile meetings here, followed by a discussion on the social implications of introducing the proposed IT-support for Mobile Meetings.

The field study was conducted at a department in an IT company owned by a Swedish local government. The department has about 25 employees, mainly working with Lotus Notes development, deployment, administration and support. All of the employees are engaged in highly qualified tasks, i.e. knowledge work.

One thing that became abundantly clear during the study was that, even though they where not out of the office very often, they were constantly on the move, talking with colleagues, asking questions and so forth. This is clearly an example of local mobility. The rest of the

study focussed on understanding their reasons for being locally mobile. What where they doing, and for what purpose?

2. Mobile Meetings

The main activity performed while being mobile was having small, short, ad-hoc meetings about emerging problems. These meetings can neither be characterized as informal communication (Whittaker et al. 1994) since they are directly concerned with work and are initiated with a specific, work related purpose in mind. Nor are they traditional meetings with predetermined agendas. They clearly share aspects of both but are neither. These ad-hoc, yet work related meetings, which we denote Mobile Meetings, seemed to play an important role in the day-to-day business at the department.

We observed three major characteristics of mobile meetings. (1) Establishing meetings is handled through being mobile and complex social negotiation between potential participants resolves whether a meeting will be initiated or not, (2) they typically concern a limited but diverse number of topics, that is, they handle multiple threads and finally (3) the most common activity during mobile meetings is briefing the other participants on past, current and future events.

Mobile meetings where commonly initiated in corridors, in the coffee room or in other open places ("Just the person I wanted to see..."), but mostly they were held in someone's private office ("I want to know what you think of this."). When arriving at (for instance) an office with the intention to start a mobile meeting social negotiation takes place. Depending on what people are in the room, to what extent they are busy and the urgency and relevance of the initiators errand, a meeting is either established or not. If it is established while another meeting is in progress a reconfiguration of that meeting will take place. Thus the focus of the discussions in mobile meetings frequently shifts. Since meetings tended to be interrupted quite often, it was common that topics was re-introduced over and over again, sometimes over long periods of time.

3. Supporting Mobile Meetings

Several important design implications can be drawn from the mobile meeting characteristics. Establishing meetings can be supported by supplying (1) awareness of where other people are, (2) awareness of what other people are doing and (3) help for the negotiation phase. The dynamic nature of handling multiple threads implies that (4) any IT-support for mobile meetings must be very flexible and allow effortless switching between different topics. Finally, (5) the large proportion of briefing activities should be supported by giving the user access to relevant material for any given topic or set of participants.

In order to satisfy as many of these implications as possible, we conceived of the dynamic to-do list concept. That is, a common to do list where each item represents a topic (or thread) and is related to a set of persons (representing the participants at a mobile meeting), as well as a set of relevant documents for supporting briefings.

When implemented on a 3Com PalmIII equipped with a radio transceiver (originally developed for the IPAD project at the Viktoria Institute, see (Holmquist et al. 1998)) the device can scan the environment and give priority to the to-do list items based on the proximity persons related to that item. This would support the establishing of meetings. Making the switching between items, as well as adding new ones easy would help the handling of multiple threads during and between meetings. Allowing the user to access documents related to the item (topic) in focus would also support briefing.

4. Discussion

The design implications from the study will be further discussed during the spring of 1999 and the prototype will be fully implemented the following summer. An extensive evaluation will follow. Even though we are enthusiastic about the support for mobile meetings, some questions do arise. We focus our discussion on the possible conflict between awareness and the integrity of individuals.

5. Awareness versus Integrity

By knowing where everybody is located at each moment, the mobile way of working can be supported, but how would the personnel react to being monitored this way? It is possible to build systems that monitor where people are located and store that information. By analyzing such databases, managers can find out how long coffee breaks the personnel have been taking, even at an individual level. People can, theoretically, monitor how often their colleagues are in the restroom or outside smoking.

While we believe that location is indeed a useful piece of information for supporting mobile meetings, we acknowledge the problems that may arise from an integrity point-of view. However, the location of other users is a crucial element in supporting mobile meetings. Hence, we believe that the advantages are greater than the potential integrity problems.

6. Responsibility versus Accountability

When there is a system that documents discussions as well as decisions taken during mobile meetings it implies that the commitments from discussions with colleagues will more explicit than before. Without a system to trace commitments and decisions, they are more based on the moral responsibility of each individual. Such a system will shift the focus from individual responsibility to accountability. Since colleagues can view each commitment and task, it will be evident if a task is ignored. Certainly, this is also the case without any system, but in a less explicit fashion.

The main question here is whether the shift from responsibility to accountability will change the atmosphere in the working place. Will it mean that the workers feel monitored and controlled? Will the informal discussions among colleagues change and be more defensive, since the employees know that discussions can result in commitments registered in the system? On the other hand, the explicit-making of his commitments can be something positive for an individual. It is not

possible for colleagues to falsely accuse someone of not performing their duties.

Will the increased accountability be a problem? Maybe not. After all, the personnel are there to work. At work you are faced with tasks and commitments that you must complete if you promised to do so. Therefore, we believe that the workers may perceive it as a supporting tool, since getting help to track your commitments makes it is easier to plan your day.

7. Social Negotiation versus Automated Negotiation

The negotiation preceding each mobile meeting is indeed a complex social phenomenon. Based on our study we cannot fully understand the properties of the negotiation phase. It seems that more forward persons were able to interrupt meetings more successfully than the average person, but on the whole the reasons for succeeding in establishing a meeting appeared to vary from situation to situation. The reasons for this are probably organizationally and socially motivated.

It is indeed tempting to try to support the establishing of meetings with IT. It could mean that you do not have to go to a colleague's desk just to find out that she does not want to hold a mobile meeting with you. But, if the negotiation is as complex a task as it appears, it is obvious that it would be problematic to mediate it through some form of IT support. It would probably result in many persons not using the system, since it would most likely fail to represent the actual situation.

8. Conclusion

It is easy to find integrity problems when discussing new technology. It can for instance be argued that the possibility to wire telephones or to read other peoples' email is a sufficient integrity problem to argue against the use of telephones or email systems. Despite these risks,

telephones and email are used by millions of people in every conceivable situation.

In the same manner is it of course possible to point out several potential problems that should be addressed when implementing new IT support for mobile meetings. Our position on this issue is that, even though it is possible to find integrity problems, the support suggested is mainly positive, both from an organizational point-of-view and an individual point-of-view. However, the design work is still in progress and a prototype will be evaluated in a real work setting during the autumn of 1999. Before the evaluation we can only speculate as to the effects of introducing IT support for mobile meetings.

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Fourth Paper[11]

ComCenter
Supporting Mobile Computer-Mediated Communication

Abstract

This paper presents ComCenter, an empirically informed conceptual systems design for supporting mobile computer-mediated communication. Field data is presented and analysed to set the background for the design and several important characteristics of computer-mediated communication are derived. Linq Mobilizer, a system in part derived from the ComCenter ideas, is presented and its architecture and functionality are then discussed and related to the conceptual system.

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[11] Bergqvist, J. (2000). ComCenter: Supporting Mobile Computer-Mediated Communication. In *Proceedings of IRIS 23*, Vol II, pp. 1373-1384, 2000, Uddevalla, Sweden.

1. Introduction

This paper reports on the activities and results in a joint academia/industry research and development project, where the participating parties were the Viktoria Institute and Linq Systems. The aim of the project was to design and implement new cutting-edge services for mobile knowledge workers. In order to do this, participants from the Viktoria Institute performed an ethnographically informed field study of representative Linq System's customers resulting in a strong focus on the communication needs of knowledge workers. Then a joint design effort resulted in a set of mobile communication services, which were later implemented and marketed by Linq Systems.

The importance of mobile communication support is increasing, as new organization forms are emerging where mobility is recognised as an important facet of co-operative work. An employee in such an organization will spend much of her time away from home base and the possibilities offered there in terms of access to advanced technological support for communication. Since she will still be in need of access to people and information, she will most likely engage in frequent computer-mediated communication (CMC), and the primary technology support will be some form of mobile IT device.

Until just recently, such devices usually referred to as Personal Digital Assistants or PDAs, have been very limited in their networking capability and mostly used as high-tech calendars and address books. Technological advancements are now changing this; PDAs are merging with mobile phones and becoming something quite different. These hybrid devices have been dubbed "Communicators", and prominent examples are the currently available Nokia 9110 Communicator and the recently revealed Quartz from Ericsson and Symbian. The combination of greater processing power and wireless communication promises many new opportunities for supporting mobile person-to-person communication.

Regardless of platform, if better mobile CMC systems are to be designed, it is important to have an understanding of what the current use of CMC at home base is like. To accomplish this, observations were

conducted in a high-tech office environment and excerpts from the collected field data are presented in this paper in order to highlight some important characteristics.

This paper describes this process in two main sections, an analysis section consisting of field study excerpts and a set of derived requirements and a design section constituted of a conceptual application (ComCenter) meeting the design requirements and a systems description of the application actually developed (Linq Mobilizer). These sections are followed by a discussion on how the current technological constraints impacted on the final design.

2. Activity Based Computing

Activity Based Computing (Norman, 1998) is an approach for designing IT artefacts and it is the inspiration behind the design of ComCenter. It was chosen due to the clear relationship between task and tool. The focus is to establish how the right tools can be presented to the user to deal with the task at hand.

> "Instead of long menu commands, one would have a chest of tool from which to select, much like working on a project in the home, where you select only those tools needed for the task and have only those at the worksite; activity spaces would allow just the needed selection. But, just as in the home where it is possible to go back and get another tool, it is possible in an activity space to add or subtract tools as needed." (Norman, D, 1998 p 85)

There are four concepts in activity based computing that are highly relevant for this paper. These are activities, tasks, actions and activity spaces.

Activities are what a person is actually trying to accomplish, and consist of goal directed sets of tasks. *Tasks* are the sets of low-level *actions* that the person needs to perform in order to accomplish the activity. Activities can be perceived as taking place in *activity spaces*, "rooms" where all the necessary tools, information etc are collected and available for performing the specific activity.

3. CMC in the Office

To design an activity space with a suitable set of communication tools for mobile workers, studies of actual CMC is required. It is difficult to empirically study the use of mobile communication technology more advanced than the mobile telephone, since it is still in its infancy. A study of CMC in a stationary high-tech office setting was deemed "the next best thing" as it is an environment with mature and frequent IT-use.

3.1 Research site and method

This research was conducted at an IT company in Göteborg, 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 close to 300 persons, and the annual turnover is approximately 280 million SEK (approximately $30 million).

The department investigated has about 25 employees. Their 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 has her own office. Everybody else either shares office or works in the office landscape.

The field study was inspired by "Quick-and-Dirty Ethnography" as presented by Hughes et al. (1994). The use of ethnography to gain knowledge of the work practice has been extensive in the CSCW field (c.f., Button and Harper 1996, Bower et al. 1995). Approximately 70 man-hours were spent 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 continuously. The material presented here are translated extracts from the field notes, the aim of which is to illuminate some important characteristics of computer-mediated communication. The names of the observed employees have been changed to ensure anonymity.

3.2 Field Note Excepts

The person in focus in these excerpts is Ursula. She works in the office as project leader and coordinator. She shares her office with two other employees, Annie and Stephen. These excerpts were selected because they give a representative picture of what a typical afternoon is like for Ursula. The italics point out important aspects of each excerpt.

Time: 11.25

(1) Ursula returns from her break and checks for messages on her mobile phone (it rang while she was away). She calls back and says, "You can't go for lunch!" They discuss how they should charge for David's teaching *[First interaction regarding David. Note that David's desk is located in the next room less than twenty meters away.]*.

Time: 11.35

[Ursula goes out to lunch and runs a number of errands.]

Time: 13.15

(2) Ursula checks where the afternoon meeting is going to be but that information is not available in the summons. She locates the phone number for another person who is attending in the Göteborg telephone database. She calls and is told that the meeting will be held on the premises. She adds a comment (reservation) in the group room booking system. *[Communication to compensate for missing information. Use of a company global contacts database to locate the communication partner.]*

(3) She writes an email to David telling him that payment for his teaching is OK and that Elaine will look into the need for authorization for some of the attendees. She also reminds him to register the training day in the KO database for the "quality people". *[Second interaction regarding David]*

(4) Ursula adds a business card to the KO database (she reads the information from a note on her desk and then throws it away). She

comments that “one of the curses in the system” is that if you enter an unused Category name it is immediately created. That means that if you enter just LINQ instead of LINQ Systems you suddenly have two Categories for the same company. A message window appears and alerts her to an impending meeting. She uses a workaround to get the alternative company name registered by entering “Misc.” as Category and pastes the company name in after the contact person’s name. *[Complex activities for managing contact information]*

(5) Then she walks over to the meeting room where Stephen and Elsie are working on the projector. Stephen and Elsie pick up the portable projector and leave. Ursula removes a non-matching chair and quickly clears the table. While doing this she accepts a short phone call on her mobile. *[The mobile phone allows communication with remote party while performing tasks away from the desktop]*

Time: 14.00

(6) The meeting is held and Ursula returns to her office.

Time: 16.00

(7) She writes an email to Edward telling him to go to a meeting as discussed during the previous meeting. *[Ursula briefs Edward who was not present during the meeting.]* Her mobile rings while she is writing and it turns out to be a private call. When the call is ended she finishes the email and sends it. *[Ursula pauses in the middle of one interaction to deal with another, triggered by the ringing phone.]*

(8) She makes another call and leaves a message on an answering machine “The meeting agenda turns out fine. See you tomorrow.”

(9) She proceeds to read an email from Mary “I’m missing your working hours for September 10”, when the mobile rings again and a discussion about where a conference should be held takes place. When the call is finished she tells her colleague across the room that there is a problem with the conference location. Annie replies that the invitations must be sent out really soon and they talk for a few minutes about what activities should be provided for the conference attendees. After that Ursula replies to the email from Mary “Came in 08.15. Left 17.00.” *[Ursula pauses in the middle of*

one interaction to deal with another, triggered by the ringing phone, which in turn triggers a face-to-face interaction. She then resumes the initial interaction.]

(10) Ursula receives and email from David telling her that the necessary information is already in the KO database. *[Third interaction regarding David.]*

(11) She answers her ringing mobile phone. It is a call from her six-year-old daughter and she spends a few minutes talking to her. *[Private communication in a work related setting.]*

(12) Then she receives an email from Andrea, who writes that she suddenly has someone else's calendar on her desktop and she wonders why. Ursula calls Andrea and tells her that it isn't a problem and that she must have accessed it accidentally. Everyone at the company has open calendars and only private items are hidden. Ursula hangs up. She comments on the issue to Annie who replies that something similar happened to here once. *[Ursula switches channel from email to telephone and also interacts with her co-located colleague]*

(13) Ursula writes and sends an email to the administrators asking them to add Andrew to a database and then calls Andrew. He hasn't the time to talk right now so Ursula tells him that they can get in touch later this evening because she is taking the relevant papers home with her. She picks up the papers and rushes out of her office and leaves for the day. *[Interrupted communication attempt leads to planning of future communication.]*

Time: 16.50

3.3 CMC Characteristics

A number of different characteristics of CMC can be derived from the field notes as represented by these excerpts. Large quantities of empirical data, which further supports these characteristics, were collected.

- The communication acts are to a large extent situated, that is, they are unplanned and triggered by occurring events. Two important distinctions can be made regarding the trigger events.
    - The first class of trigger event is *responding to the communication acts of others*, such as answering a ringing phone or replying to an email. This category can be further subdivided into signalling and content. Communication *signalling* that triggers immediate response, such as the ringing of a phone, and communication signalling that does not, such as an incoming email, and communication *content* that triggers immediate response, such as an urgent request in an email, and content that does not.
    - The second class of trigger events is *responding to triggers in the environment* such as missing information that must be compensated for by communication with other parties.
- There are also indications of non-situated communication, where communication is planned in advance. An example of this is when Ursula tells Andrew that they can "get in touch later this evening". When that communication takes place it is planned or at least prepared for in a manner different from the communication in the examples above.
- Another observation is that the *nature* of computer-mediated communication is unpredictable, as well. As shown in the excerpts, Ursula's daughter suddenly calls her in the middle of the working day. The ubiquity of mobile CMC makes you available for private as well as work related communication at all times. The consequence is that in some manner a person must be able to effectively deal with private communication as well as work related communication. Presumably this would put serious strain on different automated filtering techniques that can be employed for managing communication.
- As shown in a number of studies including (Bergqvist et al, 1999) face-to-face communication is an activity largely managed with social protocols. This appears to be an interesting approach for dealing with CMC as well. Some form of *awareness support* can be

implemented; simple things to begin with, such as the possibility to publish situational and contextual information regarding yourself, making the decision regarding which communication channel to use and whether to contact you now or later a more informed choice for the calling party.

- The large number of different persons with whom it is necessary to interact during a working day suggests that access to a company wide contacts database rather than only a limited personal database is needed.

- The amount of communication activities as well as the disruptive and intertwined nature of simultaneous multi-channel communication indicates that effortless low overhead switching between different channels is needed. Putting a low priority communication act on hold to deal with a more pressing one is necessary functionality in CMC support, even if effective communication filtering techniques are developed. The complex social nature of person-to-person communication would appear to make good-enough filtering unlikely in a near future perspective.

- As shown by Ursula's way of dealing with missing information regarding the afternoon meeting implies that access to the calendar is necessary and from within calendar items with references to people it should be possible to directly contact those persons (especially) if they exist in the contacts list.

- There appears to be a need for keeping track of multi-channel communication threads over time as indicated both by the recurring nature of the communication with (and regarding) David.

4. Mobilizing CMC

In this section an attempt is made to extrapolate how the communication patterns observed in a stationary setting can be supported in a mobile setting. The communication patterns of mobile workers may develop radically different than observed stationary

patterns, but until (if ever) mobile work becomes dominating, the stationary communication pattern must be accommodated if the mobile worker is not to become isolated and miss much needed communication opportunities and lose competitive advantages.

From an activity based computing perspective, the top level activity throughout the excerpts is person-to-person communication. Tasks involved are reading mail, composing mail, receiving a phone call, placing a phone call, locating a communication partner, switching between channels, putting a communication act on hold, resuming a communication act etc. A mobile activity space for CMC should support all these tasks, but special care must be taken to make the integration of the corresponding tools suited to the constraints inherent to mobile communication devices. Such constraints include lower bandwidth, less reliable network connection, smaller screen size and less systems resources than what is available in a stationary desktop setting. Except for screen size, such constraints are most likely of a temporary nature, though. In order to discuss this further a conceptual mobile CMC application is described in the following section.

5. The ComCenter

The ComCenter presented here is a conceptual design, not an actual system. The first implementation partially based on this conceptual design is Linq Mobilizer, designed in concert between Linq and Viktoria Institute. Linq Mobilizer and how it relates to ComCenter will be discussed in a section below.

5.1 A Scenario of Mobile CMC Use

Peter is strolling down the street when he suddenly remembers that he has to book a meeting with Mary- Jane next Thursday. He picks up his mobile telephone equipped with the ComCenter software package. He searches his personal contact list, but he can't find her contact card. Instead he searches the company's global contact list, and sure, here she is. In the contact card he can see that she is free right now and

therefore he places a call to her. During the call Peter scrolls through his calendar for a meeting time that also suits Mary-Jane. They agree on a time and finish the call. Peter pushes the button for "add comment" and a text field appears on the display. He enters "Meeting with Mary-Jane" and stores the comment at the right place in the calendar. One hour before the meeting, Peter receives a reminder on his phone and he quickly browses his file folders and faxes the relevant documents to the meeting location. Once there he collects his printed documents from the receptionist, enters the meeting room and turns them over to Mary-Jane.

The day after he realizes that they forgot to decide who should write the project report. He glances at the calendar view and clicks on the meeting entry. Since the meeting is already associated with Mary-Jane, her contact card pops up. This time he can see that she is in a meeting and by clicking on her e-mail address he chooses to send her an email instead. He suggests that he will write the report. Half an hour later he receives Mary-Jane's answer and she agrees. Peter adds the email to his to-do list, puts the phone in his pocket and pulls out of the parking lot.

5.2 Person-orientation vs. Channel-orientation

In Communicators currently available on the market, for instance in the Nokia 9110, each communication channel (or tool), such as telephone, email, SMS, etc, has a separate user interface, which each have access to the contacts database. The consequence is that when initiating communication you first choose the channel and then the recipient. This is a *channel-oriented approach* to person-to-person communication. As shown in the field note excerpts above, people sometime start communication not by choosing the communication channel, but with choosing the person with whom they want to communicate or have it chosen for them e.g. responding to an email. This corresponds to results presented in (Bergqvist et al, 1999) and (Kristofferson and Ljungberg, 1999). Accordingly, there seems to be a need for complementing the channel-oriented approach with a *person-oriented approach* and one very simple way of doing this is to change the order in which things are done when initiating communication.

Integrate the communication channels into the contacts database instead. First you choose with whom you want to communicate and then which channel you wish to use. Minimizing application switching on a mobile device is also prudent since interaction with the device is more difficult than with a desktop computer. If all available communication tools can be accessed from within a persons contact card, the overhead activity of finding and launching applications is avoided. This is the first step towards person-oriented communication.

To realize a person-oriented design, user interface consistency needed to be established across the different communication channels available.

5.3 Cross channel consistency

ComCenter provides a homogenous interface to supported communication channels. You start off in the contact list and once you have found the recipient, you choose the communication channel by clicking on the correct hyperlink. This gives the user a single point of entry to the communication act.

It is possible to show awareness information about the recipient before starting a communication act. For instance, if the company uses open calendars, as they do at the field study site, the current calendar entry can be shown or a user specified message could be displayed. This enables rudimentary negotiation before communication is initiated, similar to how people check the situation in an office before entering [1].

Once the communication act is finished, the user has the option to store the communication act in a unified history list. Information about the recipient, the subject and the time is stored. If a telephone call or other ephemeral communication act was made, the user has the option to enter a suitable subject. This provides a single point of exit from the communication act, and the user has a consistent interface to all possible communication acts. It also has the benefits of minimizing the differences between different communication channels, and also to make the entire communication history with a specific person available for searching and browsing in one unified format.

5.4 Network access transparency

One hindrance to cross channel consistency is the fat client model that Communicators typically use, where most applications communicate with the outside world by synchronizing with a PC. Because data is replicated and stored locally, Communicators are vulnerable to inconsistency and incompleteness.

ComCenter uses a thin client model that provides a browser interface to server side functionality and data. This way there is no local data that can cause inconsistencies and the user has access to far more computing capacity and more complex services than can be realized using local resources. The user also has access to up-to-date contact information stored in the communications network of the company. Once connected the network communication is transparent to the user.

6. The Linq Mobilizer

The Linq Mobilizer (LINQ, 2000) is a client/server-based system in part derived from the ideas behind ComCenter. The Mobilizer seeks to make Wireless Application Protocol (WAP Forum, 2000) enabled mobile phones an integrated part of the communication network of companies. The application makes it possible to browse ones Exchange Server data as well ass access its functionality using a mobile phone.

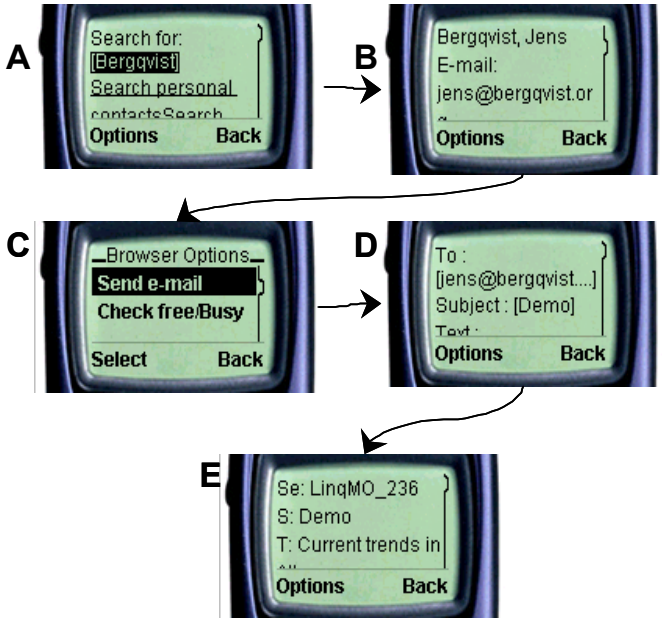

Figure 1. Example screenshots from Linq Mobilizer.

Extension modules for Microsoft Exchange (Microsoft Corporation, 2000) were implemented that make it possible to call Exchange functions directly from an ASP (Active Server Pages) script on a web server and convert the results to XML (World Wide Web Consortium, 2000), which is easily converted to other formats. The XML code is then parsed into WML (Wireless Markup Language), and transmitted to the WAP client. Modules for virtually all functionality provided by MS Exchange were implemented.

All server functions can be accessed using hyperlinks in the page description code. This makes it easy to redesign Linq Mobilizer features simply by changing the ASP scripts.

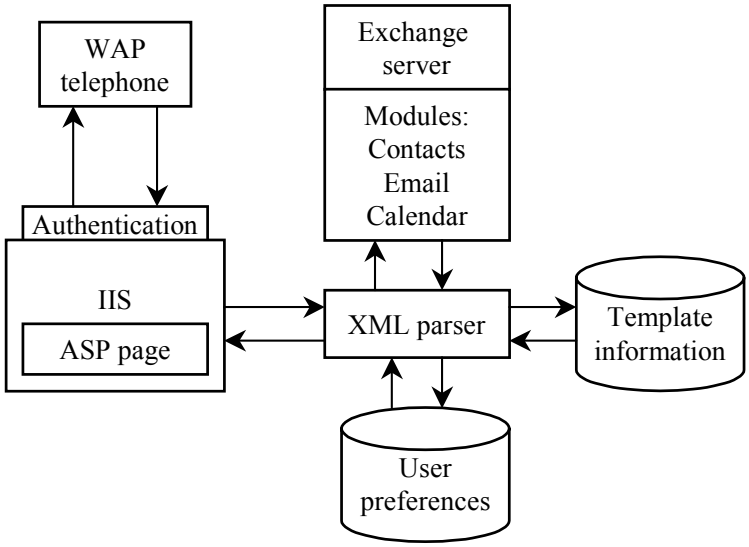

Figure 2. Simplified Linq Mobilizer architecture.

7. Discussion

The ComCenter is an attempt at using mobile IT devices, i.e. WAP-enabled mobile telephones, for supporting advanced mobile computer-mediated communication. In order to discuss the future development of ComCenter, some key issues regarding the capabilities of the current version, i.e. Linq Mobilizer, will be reflected upon.

Linq Mobilizer supports cross channel consistency to the degree that current technology allows. In the available version only email support is fully supported simply because WAP version 1.1 does not allow WML scripts to access host telephone functionality. In the next ComCenter version this will be addressed. New platforms, which support this kind of software/hardware interaction to a much better degree, will be available on within six to twelve months. For instance, Ericsson Quartz will be a complete integration between a mobile phone and an EPOC-based hand-held computer and the next generation of PDAs running Windows CE will feature much improved connectivity as well. Switching to such a platform will also provide the facilities for designing more elaborate user interfaces.

Linq Mobilizer also fully implements network access transparency. Once connected to the server, the user has full access to

the email account, the calendar, etc. The complete contact database from the company intranet is also available. It can be searched as easily as local contact lists are in other kinds of Communicators. The thin client approach means that the system relies on network connection. However, if Linq Mobilizer should lose its connection to the server, the user can still use the interface natively provided by the mobile client, since Mobilizer is an "add-on".

The real limitation of Linq Mobilizer is actually the current GSM mobile telephone network. GSM is line-switched like the ordinary telephone network, meaning that both voice and data traffic require exclusive access to the available network connection. No simultaneous voice and data traffic is possible. Within the year the first generation of GPRS networks will be available in the major cities in Scandinavia, however. GPRS is packet switched and provides functionality similar to that of the Internet. GPRS allows multiple devices and services to share connections and that means not only that a mobile device can be constantly online, but also that all kinds of data communication can take place concurrently as long as it is packet-switched. For instance, voice and data can be transmitted simultaneously. In fact voice communication becomes data communication. It also provides much higher bandwidth than the 9600 bits per second currently available in most GSM networks.

For ComCenter this presents opportunities for implementing much more advanced functionality. The always-online capability means that there is no delay in connecting to a server over the wireless network, better awareness functionality can be implemented with frequent updates of state and position and the different communication tools and channels can be further integrated.

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