JYVÄSKYLÄ STUDIES IN COMPUTING 18

Mikko Kovalainen

Computer Mediated Organizational Memory for Process Control

Moving CSCW Research from an Idea to a Product

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UNIVERSITY OF JYVÄSKYLÄ

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ABSTRACT

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This study provides a rare examination of the development process of collaborative applications from a research idea into a commercially introduced software. The research challenge here is to investigate how to enhance the communication and information sharing in process control environments with computerized tools. Such environments can be characterized by time-criticality, complexity and turbulence.

The study deploys the technological, human, and business approaches into a research driven system design. It draws upon experiences of a more than six-year longitudinal and constructive research project focusing on the design, adoption and tailoring of computer support (organizational memory) for process control environments. A theoretical approach of the study is based on the theories and concepts presented in the CSCW literature. The study utilizes multiple research and system design methods such as participatory design, ethnography, prototyping, interviews, brainstorming, questionnaires, pilot-testing and log data analysis.

The major outcome of the study was a commercial electronic diary application that can be used as a knowledge intensive resource in process control environments. The empirical results show that the electronic diary transformed ‘passive’ manual diary entries into interactive processes. The analysis implies that the electronic diary enables ‘peripheral awareness’ without spatio-temporal boundaries. The study indicates that a traditional research setting, where a research process is seen as a predefined and unitary methodology, does not match well with system development. The study provides insight into the flexible use of research methods in system development. Together they offer a fruitful framework for the development of collaborative functionalities. Finally, the study highlights critical issues related to the technology transfer and tailoring of collaborative applications.

Keywords: CSCW, organizational memory, system development research, user-centered design, technology transfer, commercialization, process control

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I tramped the rocky road 'from research idea to product' together with my research and business colleagues Esa Auramäki, Markku Hurskainen, Jarkko Marjasalo, Tuomo Peltola, Kimmo Rusanen, Santtu Salminen and Teemu Vidgrèn. It was a unique experience of which only a tiny piece has been captured into this thesis. Thank you for those unforgettable years!

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Mikko Kovalainen
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LIST OF INCLUDED ARTICLES

I Auramäki, E., & Kovalainen, M. (1998). In Search of Organizational Memory in Process Control. In Y. Waern (Ed.), *Co-operative Process Management: Cognition and Information Technology*. London: Taylor&Francis, 187-202.

II Kovalainen, M., & Robinson, M. (1999). Experiences of Different Methods in the Research and Design of an 'Organisational Memory' for Process Control. In *Proceedings of String Processing and Information Retrieval Symposium & International Workshop on Groupware (SPIRE/CRIWG'99)*. Cancun Mexico: IEEE, 353-362.

III Auramäki, E., Robinson, M., Aaltonen, A., Kovalainen, M., Liinamaa, A., & Tuuna-Väiskä, T. (1996). Paperwork at 78 k.p.h. In *Proceedings of CSCW'96*. Boston: ACM Press, 370-379.

IV Kovalainen, M., Robinson, M., & Auramäki, E. (1998). Diaries at Work. In *Proceedings of CSCW'98*. Seattle: ACM Press, 49-58.

V Kovalainen, M., & Robinson, M. (2001). From Research Idea to Product. Submitted for publication.

VI Kovalainen, M. (2002). Tailoring an Electronic Diary: 'What if it becomes too complicated?'. *Department of Computer Science and Information Systems: Working Papers WP-38*. Jyväskylä: University of Jyväskylä.

Other related publications

VII Robinson, M., Kovalainen, M., & Auramäki, E. (2000). Diary as Dialogue in Paper Mill Process Control. *Communication of the ACM*, 43(1), 65-70.

VIII Auramäki, E., Kovalainen, M., & Paunonen, H. (1995). Tools for Cooperative Work in Paper Mills. In L. Norros (Ed.), *Proceedings of 5th European Conference on Cognitive Science Approaches to Process Control*. Helsinki: VTT Symposium 158, 280-289.

CONTENTS

PART I

INTRODUCTION

1 BACKGROUND

This section identifies trends that we faced when launching the research project in the beginning of the 1990's resulting in this thesis. The purpose of the description is to understand the developmental challenges that prevailed at that time and which were reflected in the foundations of the dissertation. These trends have now become an inherent part of every day work practices in process control. Almost ten years ago, however, most of them were only promising opportunities seen dimly in the horizon.

In the industrial high-tech product development process a balanced emphasis has to be devoted to the understanding of the human, technical, and business factors (Turner, 1987) that together contribute to the success of the product. These different perspectives sometimes conflict, and thus need to be fitted together in a productive manner. In order to manage these contingencies companies often form interdisciplinary design teams that seek to build a common view during the product development process. Usually the development of a new product is initiated by identifying the opportunities for innovation. The actual process of product design is then an evolutionary task that requires designers to first understand the context in which the artifact will be used. Developers must 'jump' into the context and gather experiences from it. This demands that developers observe the users' work processes and listen carefully to their insights about the work. The aim of this process is to find answers to questions such as who, what, when, where, how, and why. Development teams need simultaneously to apply appropriate methodologies to understand the diversity of the users' demands and discover prominent usage patterns. This is crucial because the products will be embedded in both physical and social environments. Based on the outcomes of these explorations the intended product can be illustrated, interpreted, and visualized through prototypes. A prototype may be developed in close cooperation with the real users who can experience and test it in actual use. Prototypes are modified and re-evaluated according to the user's needs until compelling aspects have been discovered and embedded in the end product.

Similar design practices can also be perceived in modern software development. Originally a major focus in software development was on

technical issues such as the use of modeling techniques, data analysis, data base schema, performance, and optimization. Since the mid 1980's information systems research has also tried to explore human and social aspects in software development (see Hircheim, 1985). In this dissertation I attempt to place software development into a framework that combines human, technical, and business aspects while trying to refine 'a research idea into a commercial software product'.

In the beginning of the 1990's while initiating research underlying this thesis, several organizational and technological macro trends were emerging. The most important macro trend is illustrated in terms of information or information society (Castells, 1996). These trends illustrate a phenomenon where information and knowledge play an increasingly important role in our daily lives. In corporations these trends were clearly seen in networked business models and collaborative work practices. One important challenge was to understand how crucial information and knowledge could be captured, represented, stored, searched, and shared within and between different organizational levels. For example, Lotus Corporation (1995) formulated the importance of knowledge management:

> "Knowledge management (KM) is an organization´s ability to know what it knows, to harness and coordinate what it knows, and to add quickly to what it knows. KM increases organizational innovation, responsiveness, competency, and efficiency."

The main catalyst behind this trend was information technology. The emerging Internet provided new opportunities for software developers, as well as user organizations. Software developers tried to develop new applications to support collaborative work. They formed a 'technology push' side keen to provide innovative products to build new business practices. A 'demand pull' emerged when user organizations started to seek a competitive advantage while implementing these products. Both sides recognized the opportunities of information technology.

Michelis et al. (1998) define three facets of information systems as follows: "…the work practices, organizational structures, and the way information systems are developed and deployed, are all interdependent, but also independent factors in that none can be reduced to the others". In consequence, the development of software tools to support collaborative work practices is not solely a technical task but forms a multidimensional exploration in which versatile approaches are needed to understand the user context, to recognize user needs, and to capture and design prominent requirements into a computerized tool. However, in practice, the design of collaborative tools has proved to be based more on intuition of how people interact, communicate, and share information in the real work environment than a careful investigation and analysis of work practices.

From a business point of view, the challenge is to find appropriate ways to manage the evolutionary process of moving an innovative idea into a robust commercial product. A great portion of time, resources, and expertise are

needed to refine vague ideas into a successful product. Commercialization of innovations forms a big challenge especially for small IT-companies. Yet, only recently have topics related to commercialization received academic interest. This is partly due to an increasing number of high tech companies that are launching research and development projects together with universities. A new challenge for the academic world is to find more suitable ways of undertaking research to better support the needs of commercial product development.

In conclusion, all the trends described above influenced the essential decisions that we had to make during research. These include the selection of the research domain, partners, a theoretical background, methods, and target technology. They also guided posing the research question and setting objectives.

The rest of the introduction (Part I) is organized as follows. Section 2 introduces the research domain, approach, and process. Section 3 analyses the strengths and weaknesses of research. Section 4 defines the research question, objectives, and the methodological approach followed in this thesis. Section 5 outlines the organization of the dissertation and gives a brief summary of each article. I also point out my own contribution with respect to included articles and development process. Finally, section 6 summarizes contributions, discusses the validation of research outcomes, and observes the limitations of the research and identifies avenues for future research.

2 RESEARCH APPROACH AND PROCESS

In this section I present the background related to the research domain, and describe rationalities underlying the selected research approach. Finally, I outline the research process that was followed in the study.

2.1 Research approach

The initiative for the research reported here came from a process control system vendor. The development focus of computer support in process control environments was shifting from basic automation systems on more 'informating' and communicative process control systems (see Paunonen, 1997). Paunonen described this trend as follows:

> "Today system support for collection and utilization of experience knowledge is as poor as that for design knowledge … however, collecting experience in electronic form has been started…", and " in the future organization-related roles, information exchange, knowledge handling, development and learning will gain in importance."

In the winter of 1993, a process control system vendor suggested that we conduct a joint study to find if emerging group technologies could offer more advanced support to the work practices of operators. The operators work on the shop-floor in process control environments, and their work context can be characterized by time-criticality, complexity, turbulence and uncertainty. A common feature of work practices in process industries is that they are continuous processes operating in 24/7 shifts. Such a continuous process control is typical in energy, oil refining, pulp and paper, steel industries, and environmental plants (e.g. sewage treatment plants). Shift work also emerges in crisis management, air and traffic control, military forces, hospitals, police and rescue services, and tele-operator'-call centers. This kind of work requires successful communication and information sharing between workers. The effects of flawless and smooth work practices can be outstanding: enormous economical benefits, the saving of human lives, and the avoidance of

environmental catastrophes. For example, the downtime cost in a paper mill can easily be $20,000 per hour.

Work processes in process control are widely supported by a number of process automation and information systems. This research was one part of a larger research and development project targeted at the development of more advanced process control systems with additional informative and communicative features and functions.

The theoretical background underlying this research is mainly related to the CSCW (Computer Supported Cooperative Work) literature. In our research we made an equal effort to understand the work practices of operators (CW), and at the same time to develop computerized tools to support (CS) these practices. CSCW research tradition offered the best match to effectively combine these different approaches.

The research arena within CSCW has been diverse. Different theoretical approaches have been presented to better understand and support collaborative work. The emphasis of these studies has varied from computer support to understanding the social context of groupwork. Schmidt et al. (1992) put these completely different approaches together: “CSCW should be conceived of as an endeavor to understand the nature and requirements of cooperative work with the objective of designing computer-based technologies for cooperative work arrangements”. As they point out, the role of the work studies is to support the design process of computerized cooperative work – “CSCW is basically a design oriented research area”. In this study I support this definition and use it as a driving force throughout the thesis.

Based on our initial empirical findings in process control we found that organizational memory (OM) was the most suitable theoretical concept to characterize the functionality of the tool we were going to develop. During the interviews and discussions between workers and managers features related to OM were chosen and referred to more often than other CSCW concepts. Empirical studies also revealed that the different modalities of memory form an inherent part of the daily work practices of operators. Consequently, computerized artifacts can effectively support some parts of this memory.

2.2 Research process

Our research and development process can be divided into three phases according to a general technology development model. It divides a development process into three phases based on technological uncertainty, and the time and resources allocated to a project (see figure 1).

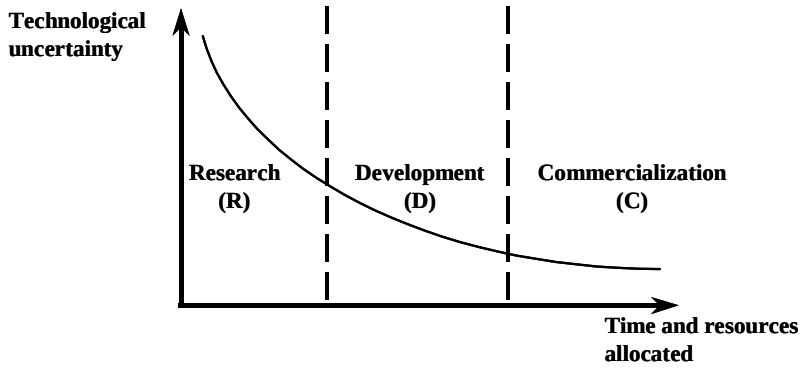


FIGURE 1 Research process of this thesis

Uncertainty is often high when creating completely new innovations. In our case, we first conducted a number of fieldwork studies to find an appropriate theoretical approach and to identify the opportunities for innovation (Research phase; R). After this, a couple of interesting theoretical ideas were formulated and 'represented' using prototypes. Then, together with the industrial partners, we selected the most promising ideas for further development based on commercial potential (D). In the development phase the prototypes were piloted and tested by end-users. In the last phase (C) the prototypes were refined into a commercial application. In this stage the technical and business aspects were molded together. An important part of commercialization was the tailoring of an application according to the varying needs of end-users. This process still continues, but initial experiences have already been observed and evaluated, and they will be reported on in this thesis.

3 RELATED RESEARCH

In the CSCW research a large number of studies have been conducted that contribute to our understanding of computer supported collaborative work practice. Each of them has a relatively narrow scope, however, and addresses only a small set of issues instead of covering the whole design process from a research idea into the product. Therefore, I will develop 'an umbrella' that ties these fragmented research topics together. It recognizes the complexity of system design for collaborative work as a whole, and seeks to identify the strengths and weaknesses in the current research.

The organization of this section combines a general technology development model, a system development research framework presented by Nunamaker et al. (1991b), and key components of computer supported (CS) collaborative work (CW) development. Nunamaker et al. (1991b) divide the research process into different steps in a development cycle: theory building (TB), system development (SD), observation (OB), and experimentation (EX). The following figure roughly outlines and categorizes different concepts used in this chapter.

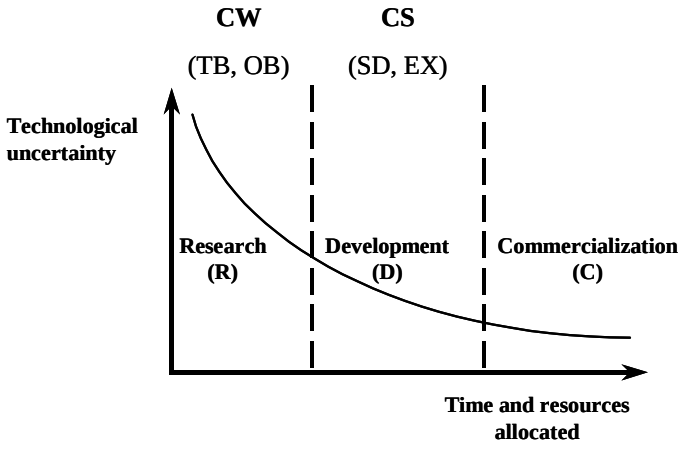


FIGURE 2 Categorization of concepts used in this chapter

The different phases of each technology development (R, D, C) are discussed in separate sections. Each consists of a short presentation of relevant studies, a brief synthesis of the study area, and the main conclusions with respect to our research.

This section is organized as follows. First (R), I introduce promising theoretical frameworks (TB) that were selected based on their relevance to my research. I then present a number of empirical studies (OB) conducted in different work contexts. After this (D), I describe how to 'represent' work practices (SD) in order to support subsequent design, and which kinds of OM-applications (SD, EX) have been developed to support them. Finally (C), I outline how work analysis can support product development and make concluding remarks about related studies.

3.1 Research phase

3.1.1 Relevant theoretical frameworks in CSCW research

Different theoretical frameworks have been introduced in CSCW research to better understand the nature of collaborative work, and to build useful computer support for it. Winograd (1987) outlined the communicative aspects of groupwork. He presented a theoretical framework based on speech acts and conversation theory where language is interpreted as action. He also explored its consequences on system design. Auramäki et al. (1988) extended this when introducing the SAMPO method (Speech Act Theory Based Modeling Approach) to model and analyze the discourses. Tuomi (1996) applies the communicative nature of groupwork and presents the communication view on organizational memory (OM). He defines organizational memory as "the landscape of accumulated organizational history through which organizational communication flows" that is needed to support organizational learning and innovation processes.

Engeström et al. (1988) and Kuutti et al. (1992) apply a theoretical framework called activity theory. Here, a social activity is described by using the concepts of actor, activity, and object, where actors transform objects when engaged in a certain activity. Bannon et al. (1996) use this approach to define the role of organizational memory as an activity of remembering where "each action of memorizing or storing information and each action of recalling and remembering take place in the context of an activity".

Ackerman et al. (1998; 2000) and McDonald et al. (1998) apply distributed cognition in analyzing the role of organizational memory in a work setting. They state: "The distributed cognition view of a network of artifacts and people, of memory, and of processing, all of which are bound by social arrangements, provides a deeper and ultimately more usable understanding of organizational life" (Ackerman et al., 2000). According to their study OM is seen as both an object, and as a process.

Malone et al. (1990) introduce coordination theory. They see a need for “the interdisciplinary study of coordination that focuses, in part, on how people work together now and how they might do so differently with new information technologies”. Coordination is defined as how activities can be coordinated, and how actors work harmoniously together. The interdependence between activities can be analyzed in terms of common objects. Schmidt et al. (1996) outline an approach to CSCW design based on ‘coordination mechanisms’. They state that “individual and yet interdependent activities must be coordinated, scheduled, aligned, meshed, integrated, etc – in short: articulated”, and “computer based systems can enhance the ability of cooperating actors in articulating their activities”.

Suchman (1987; 1996) suggests a theoretical framework for CSCW research where the key issue is how to design technologies with an explicit concern for the socially organized work practices of their intended users. Kling asks (1991) why CSCW applications have been so slowly adopted. He states that “fundamental and sometimes subtle social processes in work strongly influence the ways in which CSCW applications are adopted, used, and influence subsequent work”. He suggests that researchers should examine a variety of social relationships in workplaces in order to create more realistic images of the use of CSCW applications. The same kind of observation is also made by Grudin (1989) when he argues that the failure to address the social dimension of groupware implementation leads to user rejection of otherwise well-designed applications. Robinson (1991) launches a concept of ‘double level language’ in the sense that computer support is valuable only when it facilitates both formal and cultural (contextual) levels: “ the formal level is meaningless without interpretation, and the cultural level is vacuous without being grounded”. Agostini et al. (1997) also emphasize that communication and action events need to be embedded and contextualized into the CSCW systems. The problem here is that representations always lose some of their context, because they must first be stored into a memory (decontextualized). Later, to reuse representations, they must be recontextualized and understood in the current purposes of their use (Ackerman et al., 1998).

All frameworks described above assume that many social problems are ill-formulated. The purpose of utilizing these frameworks is to increase our understanding of the social dynamics of work. The challenge underlying computer supported cooperative work can be approached from different perspectives and theoretical backgrounds. Each theoretical framework has a partial focus that influences the way in which phenomena is seen (ontology). This can limit their field of view, misleading a researcher who is trying to understand the fundamental characteristics of work practices. Franz et al. (1988) suggest that once the researcher appropriately recognizes the purpose and time frame of his or her research focus, then choices on specific methodological issues can be made. Lyytinen et al. (1997) make an attempt to put together the key ideas of these various theoretical frameworks. They combine the social and organizational construction of groupwork, and its computer support. The groupwork is defined as a “web of coordinated social actions, performed by the

participants to achieve a joint outcome. The social actions of groupwork are situated within and normatively regulated by the organizational context".

Conclusions:

- Understanding the organizational and social context of work practice is the fundamental challenge when developing computer support for collaborative work
- These phenomena need to be properly understood and analyzed first before utilizing more specific theoretical frameworks

3.1.2 Analysis of work practices in different work domains

All theoretical frameworks presented in the previous section acknowledge the importance of understanding social context and the work-practices of groupwork. Ethnography has been the most common and widely used technique to analyze the social context of work in CSCW research. These studies have been undertaken in different work domains, such as: air traffic control (Harper et al., 1989; Hughes et al., 1992; Hutchins et al., 1996; Suchman, 1996), police work (Button et al., 1996), underground control rooms (Heath et al., 1996b), the International Monetary Fund (Harper, 1998), hospitals (Heath et al., 1996a; Harper, 1997), a software company (McDonald et al., 1998), research center (Bradner et al., 1999), mobile work (Luff et al., 1998; Fagrell et al., 1999), and a telephone hotline (Ackerman et al., 1998).

Most of these studies describe work practices as a kind of 'domain specification' whilst others evaluate existing information systems. Button et al. (1996) evaluate an existing crime reporting system and state in their analysis that the system conflicts with the practices of documenting a crime, and "thereby a system is 'irrelevant' to the practical needs of officers". Bradner et al. (1999) illustrates the communication practices of work as an interplay between the communicative practice and the social characteristics of the user groups to "assist others in understanding the technical and social possibilities that chat offers for collaboration". Both Harper (1998), in IMF, and Heath et al. (1996a) in hospitals, explore documents as an artifact or resource for communication and collaboration. They describe transformations and life-cycles of documents in organizations over time. Studies in mobile work aim at revealing the requirements to develop more flexible mobile technologies to support collaborative work. McDonald et al. (1998) define the location of expertise in the work of software designers. They introduce empirical descriptions of expertise sharing, and outline requirements for building new systems. Ackerman et al. (1998) explored where and how organizational memory 'exists' within an organizational setting. They also criticize the current emphasis in OM studies. Too few studies are based on empirical examinations of OM in real use (see also Huber, 1991; Kim, 1993; Stein, 1995a).

The most well-known and analyzed research area in CSCW is studies related to air traffic and underground control rooms. These deal with the situated and contingent nature of work as a collaborative activity in a complex

and time-critical control environment. The basic elements of these studies have been the coordination of work and actions undertaken in a specific context. Heath et al. (1996b) describe the work of operators in underground control rooms, who rely on expertise in "producing, making sense of, and coordinating their actions and activities, and thereby in managing the problems and crises that inevitably emerge in the day-to-day operation of the service". Suchman (1996) describes the way operators relate to these problems: "…requiring mobilization of available resources into a concerted course of action, quickly forgotten once the moment had passed". On the other hand, Norros (1996) presents a view of how different incidents or problems can benefit the organization. She argues that incidents such as problems or disturbances provide an excellent basis for learning and developing professional expertise. These incidents often launch the need for operators to remember and to communicate with others, and "thus initiate the process of investigation". If this 'down-top' operative experience is systematically collected, it can be "fed back into the development of the structure, functional principles, and organization of systems" (Norros, 1996).

Most of the ethnographical work-studies analyze either work practices in a specific work domain, or evaluate existing systems. They give detailed descriptions of workspace, location of workers and equipment, work processes, and individual incidents. Observations are often short stories or descriptions of incidents that happened during the study. The conclusions are intended to inform system design of the forms of domain specification and requirements capture. Only a few studies have discussed the role of fieldwork carried out in design. Hughes et al. (1993) identify four different ways in which ethnography can be conducted with design: concurrent with design, quickly and roughly, evaluative, and through re-examination of previous studies. Harper (2000) presents a field-work -program which is based on three main components: the life cycle of information, ritual inductions and observations.

Conclusions:

- More research is needed to explore the role of OM in real business settings
- Most of the studies are targeted to inform system design, but do not offer guidelines on how to build those systems
- There is a lack of methodological discussion concerning how the work analysis can be articulated into the system design

3.2 Development phase

3.2.1 Participatory design as a collaborative design method

Participatory design, henceforth referred to as PD (see Kyng, 1991; Bødker et al., 1996; Kensing et al., 1998), is a design -approach where designers and workers

are jointly interested in design, and implement technologies based on the needs and interests of workers. This approach is based on close collaboration between designers and end-users. Kyng (1991) uses the term 'mutual learning' to imply that: "designers learn about the application area and users learn about new technical possibilities". End-users will participate in development projects from the very beginning. According to Kensing et al. (1998), the end-users can play different roles in the development process by analyzing the needs, evaluating the technology, supporting the design and prototyping the system, and assisting in implementation.

Bødker et al. (1996) prefer to use the term collaborative prototyping when discussing PD. It aims "to establish a design process wherein both users and designers are participating actively and creatively based on their differing qualifications". It covers the use of computer -based tools for exploratory prototyping as well as a design that allows users to immediately participate in modifications. The driving idea is that the design activity is a learning activity mediated by different artifacts such as prototypes and design representations. To make design visible, at least two different kinds of representations of work are used: representations of the system, and representations of work. In PD approach prototypes, situation descriptions and use scenarios are the most commonly used representations. Using representations "allows end-users to simulate future work by creating hands-on exploration of emerging designs" (Kyng, 1995). Bødker et al. (1996) also argue that "the best way to improve the understanding of the usability of design proposals is to have prototypes tried out in actual use".

The significance of presentations is not, however, clear. As Bannon (1995) states: "the argument is not whether some level of abstraction and formalization of work processes is possible or desirable, but rather, whether such techniques could in principle capture all that is required, and how to manage what is inevitably left outside the representation". He raises an important question regarding the role of methods in design, and at the same time suggests that the outcomes of using such methods are only "constructions, which for some purposes, under certain conditions, used by certain people, in certain situations may be found useful, not true or false". As Suchman (1995) formulates: "The aim is a design practice in which representations of work are taken not as proxies for some independently existent organizational processes but as part of the fabric of meanings within and out of which all working practices - our own and others' – are made". Designers should be reflective with regard to both the artifacts produced by them, and the working practices provided by end-users. Bannon et al. (1996) point out that what is really required within the information systems community is "research involvement in analyzing the ways in which organizational memory – in whatever form it is conceptualized – and its computer support is built and used in real organizations by human actors in particular settings…"

Shapiro (1994) considers difference between an ethnographically - informed CSCW and PD. He recognizes three distinctive elements of PD: political engagements of PD, action research orientation, and partnerships

between designers and users. Hence, PD has a tendency towards promoting 'political' change (e.g. work place democracy) where users are actively involved in improving quality and effectiveness of their work by applying new information. Some ethnographers argue this to be too costly and time-consuming (see Bentley et al., 1992a; Hughes et al., 1993), and they believe that social scientists could mediate the role of end-users. An opposing argument is presented by proponents of PD (Kyng, 1995): "The experience of the end-users cannot be effectively mediated by representations of work or representatives of users, such as systems analysis or ethnographers".

Participatory design is seen as a promising method to capture the key features of work. The fundamental issue in this human -centered development approach is cooperation between researchers, designers, and end-users during the whole development process. What is common in each system development project is that they are unique. In each situation the developers have to face the fundamental question: how to identify, capture, represent, and verify the requirements of work practices, and how to apply these to software design? This is extremely challenging when developing computer support for collaborative work practices.

Conclusions:

- The co-operation between researchers, designers, and workers during the design process is seen as important
- There is a lack of methodological discussion concerning how work-practices can be made visible

3.2.2 Application domains supporting OM

Theoretical underpinnings that were involved in the development of the first computerized OM applications were based on conceptualizations of organizational learning. Kolb (1984) describes how individuals learn from direct experiences, and the experiences of others. Levitt et al. (1988) discuss how organizations encode, store, and retrieve these experiences into and from organizational memory. Kim (1993) argues that organizational learning is possible when mental models of individuals have first been made explicit. This opens a door to shared understanding and shared interpretations. He defines a relationship between organizational memory and organizational learning by stating that "memory affects what we learn and what we learn affects the memory" (see also Huber 1991). In the early stages of OM research the role of computerized organizational memory was seen to serve as a repository of information (Walsh et al., 1991; Conklin, 1993; Sandoe et al., 1992; Stein, 1995a; Rao et al., 1995).

Nonaka et al. (1995) present a model that emphasizes interactions in knowledge creation. They argue that individual experiences ('tacit' knowledge) first need to be shared (socialization), and then converted into explicit concepts (externalization). These new concepts can then be justified (combination), and experienced (internalization) while 'learning by doing'. Researchers in the OM

field (e.g. Bannon et al., 1996; Tuomi, 1996) have also introduced the idea that organizational memory is an active process rather than a repository of knowledge. Most recently the role of OM has been seen both as an object and a process: "memory is both an artifact that holds its state and an artifact that is simultaneously embedded in many organizational and individual processes" (Ackerman et al., 2000).

Stein (1995b) organizes applications or tools supporting organizational memory into seven different 'camps': group / team memory (Nunamaker et al., 1991a), design rationale / discussion memory (Conklin, 1993; Konda et al., 1992; Terveen et al., 1993), project memory (Lynch et al., 1992), meeting memory (Sandoe et al., 1991), topical memory (Ackerman, 1994 and 1995; Ackerman et al., 1996), document memory (Huhns et al., 1989), and environmental memory (Elofson et al., 1991). In addition, terms such as information sharing (Rao et al., 1995), expertise sharing (Ackerman, 1994), knowledge bases (Chen, 1994), and memory-based awareness (Mark et al., 1998) have been presented to characterize the role of organizational memory.

These applications, or more often prototypes, offer an excellent overview of the variety of work contexts where the computerized organizational memory can facilitate work. Most of these applications have only a technological focus, however, and studies related to them concentrate on reporting technical features rather than real use. Also, the development of applications is usually not based on a detailed work analysis. Thus, too often CSCW studies concentrate on computer support and forget the context of cooperative work or vice versa. As Lyytinen (1989) states: "…in CSCW, equal emphasis is put on the distinctive qualities of co-operative work processes, and on questions of design: how to mold computer technology to fit into and support these work processes".

Conclusions:

- None of the related CSCW research has examined the development of OM support of the process control environment
- Most of the applications developed in the OM area are research prototypes, not commercial products, or industrial strength applications
- Most of the prototypes do not lead to the implementation or design of new systems outside the research setting

3.3 Commercialization phase

3.3.1 Technology transfer

Organizations seek continuous performance improvements by utilizing 'methods' such as continuous development, business process re-engineering and best business practices. Accordingly, organizations change the ways of

working and implement new innovations. These organizational and technological transformation processes interact over time. Technology transfer takes place when organizations adopt new technology. This process continues, however, over the product life-cycle where a number of organizational and technological transformation processes take place leaving their marks on the evolution of a particular product. Karahanna et al. (1999) argue that it is important to investigate both the adoption and continuing usage of technology in order to better understand temporal aspects in the evolution of innovation processes.

In the CSCW literature, technology transfer has been mainly probed in studies related to implementation, adoption, and tailoring. Some researchers consider these themes from the organizational point of view. Orlikowski (1992) suggests that people's mental models and organizations' structure and culture significantly influence how groupware is implemented and used. Rogers (1994) states that organizations need to be committed to and have an open and cooperative culture. Karsten et al. (1998) also emphasize the important role of organizational context and social structure in implementation.

Several studies present interesting observations about end-users' roles in the technology adoption and utilization processes. Okamura et al. (1994) see a user as a *mediator*, who adopts technological innovations into a context, modifies the context, and supports ongoing changes to the technology and context over time. Gantt et al. (1992) define the user as a *gardener and guru* who is a fellow expert or user working as a local developer and providing support for others. Trigg et al. (1994) interpret the user's role as a *tailor* who adopts technology and modifies work practices, and whose efforts, over time, allow organizations to "institute and reify the standard work practices". Mackay (1990) found in her studies that some users acted as a *translator* between the highly technical group and the rest of the organization. Eveland et al. (1994) promotes a concept of *helping relationships* (i.e. a group of people who helps others voluntarily) facilitating a continuing usage of technology.

Technical approaches to the evolution of a product deal with mechanisms to manage user interfaces and application architectures. Bentley et al. (1992b) present an architecture for multi-user displays that supports rapid user-centered development and tailoring. Likewise, Smith et al. (1998) state that the user interface tailoring mechanisms must be explicitly reconfigured, and it must be an automatic process without placing additional responsibility on the user. Litiu et al. (2000) examined a mobile component framework that allows applications to reconfigure themselves dynamically. Malone et al. (1992) described an approach where end-users create applications by using 'building blocks' such as objects, views, agents and links. These blocks can serve as "an elementary tailoring language". Moran et al. (1998) present meeting support tools that differ from the specific to the generic according to various features of a particular meeting. These generic tools can be used as a useful starting point for tailoring. Teege (2000) introduces an approach based on 'composing components' to handle flexibility and tailorability. The use of components

makes it possible to integrate different applications together. He argues that flexibility and tailorability are crucial factors for the success of CSCW systems.

3.3.2 General product development

The outcomes of work analysis in a specific domain can also support general CSCW product development. As Grønbæk et al. (1997) state: "cooperative design activities may fruitfully be incorporated in general product development projects such that analysis and design in specific work domains inform and influence the design of a general product". Product development is seen as an iterative development process where prototypes are developed in cycles, and subsequently different new product releases will be introduced. These prototypes are "artifacts in mediating the interaction between the general and the specific cycles" and serve 'as a test-bed' for general development (Grønbæk et al., 1997). They reveal specific constraints, potentials, and new design ideas, which can benefit system development. According to Grønbæk et al. (1997), one of the most important impacts of prototyping is the observation that application architecture should be platform-independent and needs to be integrated with third party applications.

Exploring both adoption and continuing usage of technology are significant when trying to understand technology transfer processes. Evolution of a product is a consequence of the interplay of organizational and technological transformation processes. An interdisciplinary approach where both organizational and technological aspects are accounted for, can be fruitful in this exploration. Important technical issues in the commercialization phase relate to application architecture, platforms, integration, tailorability and flexibility.

Conclusions:

- Longitudinal studies are needed to understand the evolution of a particular product
- Additional investigations are needed to determine how specific technical issues, essential for the success of a final product, can be taken into account in the research oriented system development

3.4 Concluding remarks

All the research evaluated above emphasizes the importance of understanding the social construction of work when developing computer support for collaboration. Only a few of them, however, were derived from an analysis of work to develop CSCW applications. For example, ethnographical studies usually aim at evaluating current systems. The emphasis is not in system development. They reflect rather upon the requirements of work processes to

inform system design. These observations are not, however, realized in an actual system development.

Studies that reported on computer support for different work domains were usually based on intuition rather than on a rigorous empirical analysis of work practice. In cases in which empirical studies and system design were combined, they were often carried out in such a manner that computer support was first developed based on designers' intuitions, and thereafter prototypes were pilot tested in some environment.

Only a few system development studies analyze and report on the system development process behind the application. Thus, transitions between work practice, methods, representations, computerized applications, and general products were covered only slightly leaving the complexity of design and technology transfer nearly unexplored.

In conclusion, the results of this survey suggest that there is a gap between the analysis of work practice, and development of its computer support. This conclusion is surprising, because the fundamental principle of CSCW research is to combine both the understanding of work practice (CW), and how to support it using computers (CS). Especially in a research oriented system development, both of these views need to be combined. Therefore, a longitudinal research approach is needed to better understand the evolution of particular computer support.

To summarize, current CSCW research has not sufficiently increased our understanding of complexities behind the development of collaborative applications from a research idea to a commercial product. This will be a challenge for research. Otherwise, there is a danger that the whole field of research within CSCW may remain as an academic exercise, and will not fulfill its mission to develop more convenient, flexible, and suitable computer support for collaborative work practices in real work.

4 RESEARCH FOUNDATIONS

This study provides longitudinal examination of the impacts of rendering collaborative work more visible in process control. Our particular research interest lies in immediate process control. In this section I first introduce research questions and research objectives. Then, I shortly describe the methodological approach followed in this thesis.

4.1 Research question

The primary *research question* can be stated as follows:

'How to enhance communication and information sharing in process control with computerized tools'

More specifically my interest is to clarify how information transfer within and between work groups can be handled in more effective ways. Later, the overall research question will be revised by dividing it into the following *sub-questions:*

- *What are the most salient features of work practice that need to be supported in work groups*
- *How does knowledge become assimilated in a computerized organizational memory application*
- *How is this application developed, adopted and utilized?*

The theoretical background of the study draws upon theories and concepts presented in the CSCW literature. I seek to characterize, clarify and analyze the role of organizational memory that is at the same time explicit, handy, transparent and an invisible element of work practice. The emphasis of this study is on the design of a commercial organizational memory application that can become a knowledge intensive resource in process control. Such resources

are critical, especially in environments which are characterized by turbulence, high uncertainty and complexity.

4.2 Research objectives

The objectives of the study can be divided into three categories (theoretical, constructive, empirical), which can be connected to Nunamaker's et al. (1991b) system development research model (theory building (TB), system development (SD), observation (OB), and experimentation (EX)) as in figure 3.

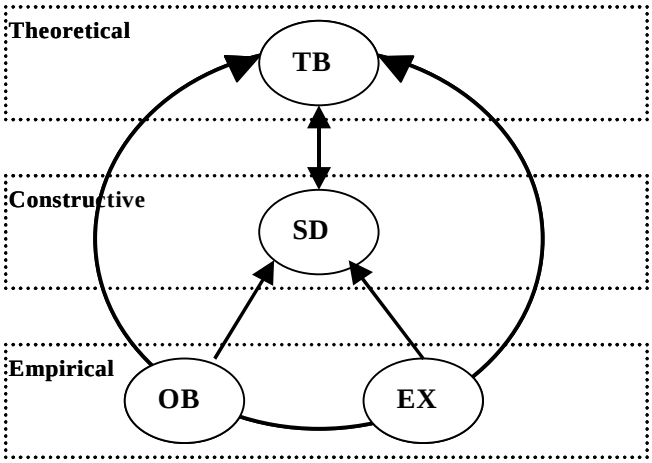


FIGURE 3 Categorization of the objectives of the study

The concrete *objectives of the study* that were derived from the research questions are:

Theoretical:

T1: Evaluate and develop appropriate insights and concepts that can be used to understand the characteristics of computerized collaborative support in the process control

Constructive:

C1: Develop technological innovations to support communication and information sharing in process control

C2: Identify the key design principles of research oriented system development

C3: Recognize the principles underlying commercialization of CSCW applications

Empirical:

E1: Define the prominent features of collaborative work practice in immediate process control

E2: Explore the role and use of organizational memory artifact to support distributed work

I address these objectives by undertaking a series of interrelated studies. These studies will be reported in the individual papers below.

4.3 Research methodology

This research is constructive in nature focusing on the design, introduction, and tailoring of computer support for process control. All individual studies share a constructivist perspective: they were conducted with the objective of informing design, to carry out requirements capture, and to develop prototypes.

We applied a wide variety of participatory methods and techniques where real users were involved in a development process from its early phases. The system requirements capture was carried out through interviews, group discussions, brainstorming, seminars and prototyping. In addition, our special focus was on exploring the role of ethnographical methods in a design. The ultimate challenge in using different methods was to get work practices, and especially interactions between workers, represented and assimilated in a suitable set of artifacts.

5 SUMMARY OF THE THESIS

The body of this thesis is divided into four interrelated parts, which consist of six individual articles. These articles are not presented in any order of publication rather they are organized according to their role in relation to the overall research theme. In this section I first describe the organization of the thesis. I then briefly introduce the main objectives and the results of each article, and finally I identify my own contribution in regard to the articles and the development process.

5.1 Organization of the thesis

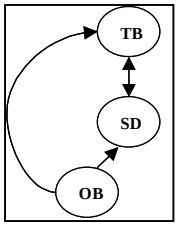
The constructive study roughly followed the general technology development model. I also use the fundamental theme of this model (from idea to product) in organizing the content of the thesis. After the Introduction section (in Part II) I outline our theoretical underpinnings and key concepts, the research approach, and the role of different research methods that have been applied during the study. Then I introduce (Part III) the major results of observations and field experimentation, and their contributions to both system and theory development. Finally, I discuss (Part IV) the topics related to the evolution of CSCW applications, technology transfer and tailoring.

5.2 Summary of the articles

Here is a brief summary of the papers. Each paper is marked by an identifier (P1-P6) and the major contributions to the research oriented system development model are illustrated in a diagram.

5.2.1 Theoretical framework and research methods (Part II)

First paper (P1): *'In search of organizational memory in process control'*



This paper was published in *Co-Operative Process Management* (ed. Waern, Y.). Taylor&Francis, 1998.

Objectives

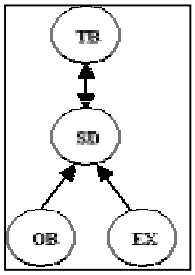
The driving force for our longitudinal research was to "find ideas on how to support co-operation and information sharing in a process control environments". In this paper we describe findings obtained when we 'went in' to the research context and tried to understand work practice. The objectives of the research were first to find an appropriate theoretical approach and key concepts that are relevant in the research domain. Second, to obtain an overall understanding of work practice in process control, and to transform these into the domain specifications and initial requirements capture for design. Third, to develop a preliminary prototype that would represent, how a certain part of the work practice could be supported by computer, and would mediate further communication between researchers and users.

In this phase we conducted about 30 hours of ethnographical observations, and interviewed a total of sixty employees including production managers, shift foremen, IT-people, trainers, project managers, and process automation and control system developers. In prototyping we applied participatory design methods.

Results

In our empirical study we found that expertise is usually tacit, unstructured and fragmented. Remembering earlier incidents played a significant role in the operators' knowledge sharing in process control. In addition, in discussions interviewees most often connected expertise and memory with each other. Based on these observations, we made a conclusion that the concept of organizational memory is the best 'umbrella' under which to describe the work context. In this paper the location of expertise and organizational memory in process control is identified and described. We built a Shaman model, which combines three important organizational processes to support OM: organizational remembering, learning, and interaction. The Shaman model shows one way of categorizing the nature of organizational memory in a work setting, especially in process control. In order to make this memory tangible, we developed a Shaman prototype that supports expertise sharing in process industry, and introduced it to the end-users. It was developed further according to their feedback. The Shaman prototype represents the structure, content and processes of organizational memory in a process industry.

P2: *'Experiences of different methods in the research and design of an "organizational memory" for process control'*



This paper was published in the proceedings of *String Processing and Information Retrieval Symposium & International Workshop on Groupware (SPIRE/CRIWG'99)*. Mexico Cancun: IEEE, 1999.

Objectives

In this paper we present the role of different methods that were used when engaged in our study to understand work practices, and to develop software to support those practices. Only a few previous investigations have been carried out to describe the practical uses of methods that support research oriented system development (Nunamaker et al., 1991b; Hughes et al., 1992; Harper, 2000). Furthermore, in the CSCW research arena there is also a lack of methodological discussion concerning how work practices can be made visible, although the appropriate use of methods and representations forms an important basis for software development.

The objective of this paper is to report our experience in using a wide variety of research methods in a longitudinal research project, and to raise discussion about the use of research methods in CSCW system design in general. In particular, we explore the role of alternative methods in developing CSCW functionality of organizational memory. Equally, our attention is focused on different representations of work practice and representations of the system being designed. We also try to validate our findings by comparing them with Harper's (1998) 'field work program'.

Results

We came to the conclusion that, in an industry-driven longitudinal study, a research approach provides overall guidelines and ensures consistency, rather than a predefined and canonical research methodology. The emphasis and direction of the project may change over time, but the research approach provides flexibly informed choices of methodology, subject selection and project directions.

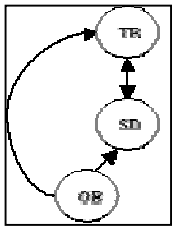
In our research, some key roles of methods were identified, such as support for a process of understanding, a tool for interpretations, an assistant for idea generation and tool selection, and a vehicle for transition and generalization. Especially methods like diagonal matrix technique and prototyping were found to be useful for representing the structure, content and process of work practice. They supported collaboration and communication between researchers and other stakeholders when establishing a common view of the research context. These methods were also important in committing key people to the development process.

When compared with Harper's (1998) guidelines for design-oriented ethnography, we found two missing factors - a friend in the organization, and

prototyping. Neither of them were included in Harper's recommendations. Our analysis did not recognize the tracking of information careers and different modalities of information over their life-times. We think that the basic reasons for these differences are different time-scales and intended outcomes.

5.2.2 Explorations (Part III)

P3: *'Paperwork at 78 k.p.h'*



This paper was published in the proceedings of *Computer Supported Cooperative Work (CSCW'96).* Boston: ACM Press, 1996.

Objectives

Our research context was a time-critical, complicated, and turbulent process control environment. No previous CSCW research has been conducted to develop computerized OM support for that context. The objectives of this study were, first, to identify both the normal and abnormal features and incidents in work practice in order to better understand the social mechanisms that underlie and support an operator's work in process control. Second, based on these empirical findings we sought to define recommendations for the support system design of the Shaman prototype. Our third objective was to find a suitable conceptualization of OM that is appropriate for our research domain.

In this study we analyzed and interpreted research data in more detail over a period of 18 months from a design point of view. Data was collected by ethnographic observation, and interviews. We also used participatory design methods when developing the Shaman prototype.

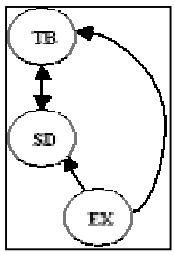
Results

We found that the breakdowns in paper production played an important and visible role in the operators' work in the paper mill. In normal situations the expertise of the operators was 'invisible', but disturbances launched the patterns of actions where this expertise was mobilized across organizational levels. The ability to remember earlier experiences and to interpret the situation became important when solving emerging problems. These experiences were stored in the minds of personnel and different documents, but sometimes they were not at hand when they were most needed. The paper break incidents are 'boundary objects' (Star et al., 1989) that pass between groups and levels, helping maintain and generate a community of practice.

A paper diary was the primary instrument in documenting incidents. Interviews in the paper mill also revealed problems as to why paper diaries were not much used. One reason was that diaries were artifacts that in some sense fulfill only the needs of management at the operators' expense (see Grudin, 1989).

The key design requirements for an electronic version of a diary were: meet the needs of operators, all workers should have access and almost all workers can make entries, easy local and organizational diffusion, opportunity to have an overview as well as different perspectives on what is going on, an emphasis on recording 'soft' information (document origination), support for local categories and indexing, a flexible but structured organization of data, and full text search features. The diary module of the Shaman prototype was developed further following these design recommendations. The driving force behind this development was the notion that organizational memory needs to allow the movement from passive storage to active structuring. We defined also the notion of organizational memory and based on our findings, used the interpretation that OM was a process rather than a thing.

P4: *'Diaries at work'*



This paper was published in the proceedings of *Computer Supported Cooperative Work (CSCW'98)*. Seattle: ACM Press, 1998.

Objectives

In this study we explore the transition of a traditional paper diary into an electronic diary, and conduct a pilot study using an electronic diary in the daily work of operators in a large paper mill. Our goal was to gather empirical data about the role and real use of an electronic diary as organizational memory. We analyze the content of about 3 500 diary entries made in a year. The objective of the study was to find the main benefits of using the diary, and to identify the value it adds to the daily work of operators. We also sought to evaluate and refine the concept of organizational memory in the process control.

Our study is based on the real log data analysis of an electronic diary. We analyze the content of each entry and track interrelations between different entries.

Results

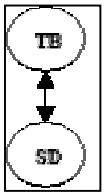
Our main contribution was the new conceptualization of OM. We found that OM is neither an artifact, nor a process, but rather an artifact mediated process. Diary entries showed us that they constitute dialogues within and between work-shifts, and they are used over different organizational levels. Indeed, the Diary was a vehicle for specialized dialogues: some comments were answered by other workers often in other shifts, some comments were not answered at all, and sometimes these dialogues extended over many weeks.

The predominant entry form was an unaddressed entry, which is analogous to 'talking out loud' and 'overhearing' in a face-to-face context (Heath et al., 1991). This forms one of the key benefits of an electronic diary, because it enables a 'peripheral awareness' of events and activities between workers extending over spatio-temporal boundaries. Another major benefit

relates to the extended dialogues that illustrate the ways in which 'search' enables the use of local categories. These local categories form part of a conversation, part of an organizational memory, and allow the movement from passive storage to active structuring. Both unaddressed entries and extended dialogues sketch a mode of computer mediated coordination that is very different from work-flow models. The usefulness of the Diary was also indirectly shown. The use of the electronic diary diffused from the original 35 factory floor workers and 2 managers to more than 100 people including 13 managers. Discussions with managers revealed that some of them used the Diary as a resource for their other work activities such as reporting.

5.2.3 System development (Part IV)

P5: *'From research idea to product'*



Submitted for publication.

Objectives

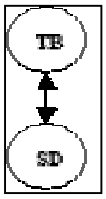
In this paper we discuss the complexity of research oriented product development. We are especially concerned with the longitudinal process of refining a research idea into a commercial product. The paper is based on our experiences obtained in developing an electronic diary into a generic organizational memory tool for process control. The diary tool is commercialized for multiple user environments, and integrated with diverse architectures, systems and user interfaces. The objective of the paper is to discuss the role of research in commercial product design, the success factors in research driven product development, the role of different stakeholders during the research process, and the integration of the software into organizational IS-architecture.

Results

We share, along with many other IS -researchers (see Hirscheim, 1985; Mathiassen, 1987; Bowker et al., 1999), the view that IT infrastructures are largely social systems, and an early integration of CSCW application into the larger IT infrastructure is important (Grudin, 1989). In our case this early integration means not only technological integration, but also organizational and social integration. We found that the social integration of various stakeholders, interests, and organizations evolved into technical integration. This social integration can be perceived as in the end-users' commitment to the project. It is expressed through 'words and phrases' that work as 'boundary objects' (Star et al., 1989). These objects mediate between different groups, departments, organizations and interests. The methods of participatory design and prototyping play an important role in the social and technical integration.

We learn that the development process is conducted in several cycles where the emphasis may differ from analyzing social practice to the technical integration of software. These processes can and should be conducted concurrently, and different methods should be applied during various development cycles. The level of technology transfer can be used to measure the success of process. In research oriented system development, the role of committed industrial partners becomes significant. Industrial partners emphasize generalization, integration and configuration of software, whereas in research the main concerns are categorization, navigation, and semantics of information. These two views together form a dynamic environment, which needs to be managed when developing a generic product.

P6: *'Tailoring an electronic diary: "What if it becomes too complicated?"'*



This paper was published in *Department of Computer Science and Information Systems: Working Papers WP-38.* Jyväskylä: University of Jyväskylä, 2002.

Objects

Diary applications have already been installed into a number of mills and plants. Now we face the complexity related to tailoring and how to manage the heterogeneous needs of different user organizations. In our case the fundamental issue was to analyze an appropriate level of standardization of collaborative features specific to each organization. This trend and cautionary examples such as Coordinator (Flores et al., 1988) and work-flow systems of bounding variety stimulated us to further analyze the fundamentals behind this phenomenon. In order to study this we analyzed specific features and functionalities of three versions of the diary. This paper demonstrates and analyzes how various collaborative features were tailored into the different diaries. The theoretical perspective of this analysis is based on the conceptual model of groupware presented by Ellis et al. (1994), and the tailoring mechanisms suggested by Teege (2000). The general objective of the study is to examine the fundamentals behind the standardization of collaborative features of the electronic diary, and to understand the complexity related to tailoring CSCW-applications.

Results

Based on our analysis we define five components – communication flow, coordination flow, awareness, openness, contextualization – that characterize the diary as a cooperative tool. These components were customized in different ways based on the intended semantics of the diary. We found that quite standardized collaborative features can make the diary too complicated to use. We conclude that a challenge for future development of the diary is to identify

an appropriate level of standardization that enables effective reuse of information without losing the user's flexibility. Our findings confirm Ellis' et al. (1994) statement that the "intended semantics of some classes of objects are the main concept behind the groupware system, and its major contribution".

We argued that Teege's (2000) statement that the responsibility in tailoring was put on the end-users, needs to be reconsidered. In this study we found that at least in time-critical environments, control of tailoring is mainly the responsibility of the software developer. Only partial control is provided to end-users. We conclude that an important issue here is how tailoring should be organized and accomplished between software developers and end-user organizations to ensure successful technology transfer. We suggest that a careful consideration of underlying control mechanisms and utilization of appropriate technology transfer processes provide a useful framework for tailoring applications, and for deciding upon an acceptable level of limiting the variety.

5.3 About the joint articles

The first article that defines our theoretical underpinnings (in Part II) is equally co-authored with Esa Auramäki. In the data collection my main contribution was the ethnographical work analysis and initial interviews.

The paper of CSCW '96 (in Part III) is co-authored with Esa Auramäki, Mike Robinson, and the development team. The development team carried out the requirement analysis and prototyping. My major contributions to the paper were related to the data collection and analysis, and writing the original description of the observations.

The 'Diaries at Work' (in Part III) was co-authored together with Mike Robinson and Esa Auramäki. I carried out the entire data collection and a major proportion of the data analysis.

The methodological paper (in Part II) and 'From research idea to product' (in Part IV) are based entirely on my own text. The original texts were rewritten into the final format of publishing jointly with Mike Robinson.

5.4 Author's contribution to the software development

The software development took place in different cycles resulting in a number of prototypes. Over the years, the actual coding of the OM application was accomplished by more than 15 researchers and software developers. They participated in different phases of the development process based on fixed period contracts ranging from several months to a couple of years. I contributed to the requirement capture and system analysis (but not coding) over the whole

development process. My main role was to direct and control the work of the development team, and to assure that the research outcomes satisfied both scientific and commercial objectives.

6 CONCLUSION

None of the post-CSCW research has looked at the development of commercialized OM support to process control environment. Most of these studies have been academic exercises, and either dealt with cutting edge technologies or architectures (CS), or empirical studies of various collaborative work environments (CW). Only a few studies combine both of these approaches. None of them, however, report on experiences that cover a whole system development cycle from a research idea into a successful commercial product.

In this thesis I explore '*how to enhance communication and information sharing in process control*' with computerized tools. More specifically the study addresses the following research questions:

1) Which are the most salient features of work practice that need to be supported
2) How does knowledge become assimilated in a computerized organizational memory application
3) How is this application developed, adopted and utilized?

We tackled these questions by undertaking a series of interrelated studies. All studies shared a constructivist perspective: they were undertaken with the objective of informing system design, to carry out requirements capture, and to prototype.

In this section I first summarize the main contributions of the thesis. I then verify our research in relation to the requirements that research oriented system development needs to satisfy. Finally, I discuss limitations of the study, and address the potential areas for further research.

6.1 Contributions

The contributions of this thesis are several. They vary from new theoretical conceptualization of the role of OM to industrial strength software and observations of using it. In the following, I first briefly summarize the main outcomes of this research, and characterize them in relation to research objectives and individual papers (in brackets: *Objective; Paper)*. Then I present the dissemination of results.

6.1.1 Outcomes

Our empirical studies reveal that the ability to remember earlier incidents and experiences is an important feature of work practice in process control (*E1; P1, P3*). Unfortunately, experiences easily remain just in the heads of individual workers, and they may not be at hand for others when most needed. Especially situations such as breakdowns in paper process, evoke communicative and information sharing processes among workers. Paper breaks have similarities with 'boundary objects' (see Star et al., 1989) that pass between groups and levels, helping maintain and generate a community of practice and shared concerns (*T1; P3*).

Organizations try to advance information sharing by means of specific work arrangements (e.g. team work), or appropriate organizational culture. In addition, organizations have developed several artifacts to support information sharing starting from the physical design of features. We found that in process control environments a diary is used as an organizational memory artifact to document important production incidents (*E2; P1, P3*). Traditionally these incidents are documented using a paper diary that is located in the control room of a mass operator. However, paper diary entries are not available simultaneously in other control rooms. This research emphasizes the development of an application that makes important incidents visible without spatio-temporal restrictions.

The major outcome of this research was a commercialized electronic diary (eDiary) product that was implemented on a number of sites. It was perceived to enhance the communication and information sharing within and between the shifts. The eDiary constituted dialogues within and between shifts (*E2; P4, P6*). Thus, the eDiary transformed 'passive' entries of the manual diary into interactive processes. It formed an alternative mode of computer mediated workplace communication that is different from structured or workflow models (*E2; P4, P6*). These dialogues were part of a conversation, and part of an organizational memory. We conclude that organizational memory was 'an artifact mediated process' instead of a passive storage (*T1; P4*). The use of the eDiary has analogues to 'talking out loud' and 'overhearing' in a face-to-face context (see Heath et al., 1991; *T1; P4*). Furthermore, the eDiary enables 'peripheral awareness' without spatio-temporal boundaries (*E2; P4*). As a result,

the eDiary was disseminated and used across organizational levels. Based on empirical studies, we also define general design principles and critical success factors for the eDiary in process control (*C3; P3, P4, P6*).

In research oriented system development, several methodologies are needed for different phases of the development process (*C2; P2*). A traditional research setting where a research process is seen as a predefined and canonical methodology does not match well with contingencies of system development. We suggest that, especially in the longitudinal projects the research approach provides overall guidelines that ensure consistency for the development process (*C2; P2*). Ethnographical research methods combined with participatory design approach were the most suitable 'tools' in research oriented system development (*C2; P2*). We found that Harper's (1998) guidelines for design-oriented ethnography fit our work well. The importance of 'a friend in the organization', and 'prototyping' were not included in his original recommendation (*T1; P2*). Similar concepts of a 'friend' in the organization such as a 'mediator' (Okamura et al., 1994), 'gardener and guru' (Gantt et al., 1992), 'tailor' (Trigg et al., 1994), 'translator' (Mackay, 1990), and 'helping relationship' (Eveland et al., 1994) have been introduced to facilitate the adoption and utilization of technology.

The use of ethnographical research and participatory design stimulates social integration among stakeholders, revives and reconciles interests, and involves organizations in the development process. The end-users' commitment to the project is expressed through 'words and phrases' that work as 'boundary objects' (Star et al., 1989) (*T1; P5*). These objects mediate between different groups, departments, organizations, and interests, and they play a significant role in technology transfer (*C3; P5, P6*). Social integration is also an important task for the technological integration of applications. Technological integration, an issue such as how to link CSCW applications into larger IT-architectures, has to be taken into consideration already in the early stages of the research process (see Grudin, 1989; *T1, C3; P5*). Finally, a crucial factor in the adoption of an eDiary is tailoring collaborative features and functionalities. Tailoring is based on the intended semantic of an application. Here we agree with Ellis' et al. (1994) statement that the "intended semantics of some classes of objects are the main concept behind the groupware system, and its major contribution" (*T1; P6*). The challenge in the tailoring of the eDiary is the identification of an appropriate degree of feature standardization that enables effective reuse of information without losing user flexibility (*C3; P6*). We disagree with Teege's (2000) suggestion that end-users have a major responsibility in tailoring. Instead, we suggest that in time-critical environments the control of tailoring mostly resides with software developers (*T1, C3; P6*). Here the challenge is how tailoring should be organized and accomplished between software developers and end-user organizations to ensure successful technology transfer.

6.1.2 Dissemination results

The eDiary has already been implemented in a number of energy plants, pulp and paper mills, sewage treatment plants, and oil refining units. The same product is also suitable for other continuous 24/7 shift work environments. One of the world's biggest pulp and paper companies has selected the eDiary to serve as a basic platform for operators' knowledge management.

The commercial version of the eDiary forms a part of the knowledge management product family of a process control system vendor. The vendor describes the benefits of the diary as follows:

> "Key benefits: …Storing, sharing and accumulating experience knowledge, changing tacit knowledge to explicit knowledge, efficient building of organization memory, continuous learning, clear situation awareness, efficient decision making based on knowledge, the organization can utilize it's full knowledge in all situations, expert knowledge in everyday work brought to the fingertips of the operators." (Marketing material 10/2000)

The paper machine manufacturer uses the eDiary to manage the reporting needs of the start-up engineers when starting a new paper machine. Its role is to share information inside a global organization. In short, different versions of the eDiary are of significant value to different parts of a business chain of pulp and paper industries.

Findings reported in this study can be used as a basis when designing more useful and sophisticated IT-support for information sharing, and knowledge management for process control. Typical use environments include energy, oil refining, pulp and paper, and steel industries, crisis management, air and train control, military forces, hospitals, police and rescue services, and call centers. Results can also be applied in the evaluation, development, and tailoring of collaborative features into existing or future process control systems.

The experiences of this study can be utilized as a guideline or roadmap when launching new research oriented system development projects, especially when the target is to refine research ideas into commercial products.

6.2 Validating research results

The longitudinal research process was divided into a number of development cycles, where the emphasis between commercial and research interests varied over time. We can evaluate and verify our research process against the five criteria that a system development researcher must confront (Nunamaker et al., 1991b).

Premise 1: The purpose is to study an important phenomenon in areas of information systems through system building.

Our research is about how to enhance communication and information sharing in the continuous process control, where ability to remember earlier incidents and experiences is an essential feature of work. The consequences of insufficient information sharing can be significant: loss of human lives, enormous economical losses, or environmental catastrophes. We used the methods of system building to analyze, capture, and represent salient features of work practice, and as a representation of the system being designed.

Premise 2: The results make a significant contribution to the domain.

We introduced a new conceptualization of OM and developed commercially successful software. These results have influenced the future design of systems to support organizational memory, and to establish, adopt, and diffuse co-operative computer tools for time-critical process industry environments.

Premise 3: The system is testable against all the stated objectives and requirements.

Empirical data showed that the eDiary forms dialogues within and between shifts. Dialogues form a part of daily communication and information sharing in process control. Other workers, often in other shifts, answer comments. Sometimes dialogues extend over many weeks, and some comments are not answered. These dialogues convinced us of the role of OM as active structuring rather then a passive storage. The study can easily be repeated again in the same or other mills.

Premise 4: The system provides better solutions to IS problems than existing systems.

The key benefits of the eDiary compared with the existing paper diary was the immediate support for ‘peripheral awareness’ overcoming spatio-temporal boundaries. The diffusion of the eDiary over organizational boundaries convinced us of the usefulness of the diary. We also found that in the research context, the dialogues formed an alternative modality of computer support to explicit structured communication. The eDiary can also be integrated into the larger IT-system architecture of an organization, and thus linked into other process control data.

Premise 5: Experience and design expertise gained from building the system can be generalized for future use.

We have reported experiences of using ethnographical methods and participatory design principles in real work settings. We concluded that the

research approach provides the overall guidelines that ensure consistency in the project. The early integration of the system into a larger IT infrastructure implies organizational and social integration of multiple stakeholders. Compared with Harper's (1998) guidelines we additionally found the importance of prototyping and a friend in the organization.

Altogether, the development process entirely fulfills all of the five premises of research oriented system development.

6.3 Limitations and future research

The results of this research are based on empirical studies in real work settings. The outcomes were important, and they have received both scientific and commercial attention. However, there are also a number of issues that need to be critically considered and evaluated before making long-term generalizations.

The selection of our theoretical approach was based on and limited to theories and concepts in the CSCW research arena. When doing this we ignored a vast number of other relevant research presented especially in HCI and IS-research domains.

We had a restricted theoretical focus in analyzing our research data. In the future, research utilizing other relevant theoretical approaches in analyzing the data would be fruitful and might open new insights to the conceptualization of OM. For example, communication theory (Auramäki et al., 1988) could be useful when analyzing in more detail the operators' dialogues. Activity theory (Engeström et al., 1988; Kuutti et al., 1992) may fit well when analyzing the expertise of operators, which is often invisible and expressed only as patterns of actions. Distributed cognition (Ackerman et al., 1998) could be utilized to analyze the eDiary as a system that is interpreted by different operators. Schmidt et al. (1996) outlined a theory of the use of artifacts for coordination purposes. This approach could be applied to analyze more deeply the coordination mechanisms of the eDiary (e.g. unaddressed entries), and to compare it with the more structured computer supported coordination (e.g. workflow systems).

So far, most of our conclusions related to the eDiary have been based on only one large log of data in one production line in one paper mill. In order to validate our earlier studies and to evaluate the changes in the use of the eDiary over time, we need to repeat the log data analysis and ethnographical observations after a two -year period, in the same production line. This could help us to better understand both organizational and technological aspects underlying the evolution of the eDiary. Ethnographical studies can be particularly effective in evaluating existing systems (Hughes et al., 1993). Also, more detailed studies related to the information life cycle of the eDiary entries would be valuable (Harper, 2000).

In order to gain more external validity and scientific generality we need to repeat these investigations also in other production environments as well. We need to repeat studies in paper mills with different production strategies and principles as well as in different work contexts such as energy, crisis management, and call-centers. Especially valuable would be comparable studies in different work domains where the work analyses are conducted before the eDiary is adopted, and after the eDiary has been taken into use. This could give us new insight into technology transfer and tailoring of the eDiary in various work environments. However, no matter how many studies are conducted in different work contexts, the generalization of research outcomes will always be a problem. This is a fundamental methodological problem of qualitative research.

One interesting research agenda that is currently emerging in CSCW literature is mobility in the workplace (see e.g. Luff et al., 1998). They define the concepts of micro-mobility, and local and remote mobility in the workplace. Concepts of mobility are valid also in our case dealing with the analyses of mobility in the operator's work, and considering them in relation to further development of the eDiary. The technological innovations already exist to support mobility in the operator's work, but suitable applications are still needed. Again, this is a fruitful theoretical opportunity to launch a research oriented system development process, and to apply the design practices and principles I have suggested in this thesis.

REFERENCES

Ackerman, M. (1994). Augmenting the Organizational Memory: A Field Study of Answer Garden. In *Proceedings of the 1994 Conference on Computer Supported Cooperative Work*. Chapel Hill NC: ACM Press, 243-252.

Ackerman, M. (1995). Memory in the Small: An Application to Provide Task-Based Organizational Memory for a Scientific Community. In J.F. Nunamaker, Jr. & R.H. Sprague, Jr. (Eds.), *Proceedings of the 28th Hawaii International Conference on System Sciences (HICSS'95)*. Los Alamitos CA: IEEE Computer Society Press, 323-332.

Ackerman, M., & Halverson, C. (1998). Considering an Organization's Memory. In *Proceedings of the 1998 Conference on Computer Supported Cooperative Work*. Seattle: ACM Press, 39-48.

Ackerman, M., & McDonald, D. (1996). Answer Garden 2: Merging Organizational Memory with Collaborative Help. In *Proceedings of the 1996 Conference on Computer Supported Cooperative Work*. Boston: ACM Press, 97-105.

Ackerman, M., & Halverson, C. (2000). Reexamining Organizational Memory. *Communications of the ACM*, 43(1), 59-64.

Agostini, A., Michelis, G., & Grasso, M. (1997). Rethinking CSCW Systems: The Architecture of MILANO. In J. Hughes, W. Prinz, T. Rodden, & K. Schmidt (Eds.), *Proceedings of the 5th European Conference on Computer Supported Cooperative Work (ECSCW'97)*. Lancaster: Kluwer Academic Publishers, 33-48.

Auramäki, E., Lehtinen, E., & Lyytinen, K. (1988). A Speech-Act-Based Office Modeling Approach. *ACM Transactions on Information Systems*, 6(2), 126-152.

Bannon, L. (1995). The Politics of Design: Representing Work. *Communications of the ACM*, 38(9), 66-68.

Bannon, L., & Kuutti, K. (1996). Shifting Perspectives on Organizational Memory: From Storage to Active Remembering. In R.H. Sprague, Jr. (Ed.), *Proceedings of the 29th Hawaii International Conference on System Sciences (HICSS'96)*. Los Alamitos CA: IEEE Computer Society Press, 156-167.

Bentley, R., Hughes, J., Randall, D., Rodden, T., Sawyer, P., Shapiro, D., & Sommerville, I. (1992a). Ethnographically-Informed Systems Design for Air Traffic Control. In *Proceedings of the 1992 Conference on Computer Supported Cooperative Work*. Toronto: ACM Press, 123-129.

Bentley, R., Rodden, T., Sawyer, P., & Sommerville, I. (1992b). An Architecture for Tailoring Cooperative Multi-User Displays. In *Proceedings of the 1992 Conference on Computer Supported Cooperative Work*. Toronto: ACM Press, 187-194.

Bowker, G., & Star, L. (1999). *Sorting Things Out: Classification and its Consequences*. Cambridge MA: MIT Press.

Bradner, E., Kellogg, W., & Erickson, T. (1999). The Adoption and Use of 'Babble': A Field Study of Chat in the Workplace. In S. Bødker, M. Kyng, & K. Schmidt (Eds.), *Proceedings of the 6th European Conference on Computer Supported Cooperative Work (ECSCW'99)*. Copenhagen: Kluwer Academic Publishers, 139-158.

Button, G., & Harper, R. (1996). The Relevance of 'Work-Practice' for Design. *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, 4(4), 263-280.

Bødker, S., & Grønbæk, K. (1996). Users and Designers in Mutual Activity: An Analysis of Cooperative Activities in Systems Design. In Y. Engeström & D. Middleton (Eds.), *Cognition and Communication at Work*. Cambridge: Cambridge University Press, 130-158.

Castells, M. (1996). *The Information Age: Economy, Society and Culture: Volume I: The Rise of the Network Society*. Cambridge MA: Blackwell Publishers.

Chen, H. (1994). An Algorithmic Approach to Building Concept Space for a Scientific Community. In *Proceedings of the 27th Hawaii International Conference on System Sciences (HICSS'94)*. Los Alamitos CA: IEEE Computer Society Press, 4, 201-210.

Conklin, J. (1993). Capturing Organizational Memory. In R. Baecker (Ed.), *Readings in Groupware and Computer-Supported Cooperative Work*. San Mateo: Morgan Kaufmann Publishers, 133-137.

Ellis, C., & Wainer, J. A. (1994). Conceptrual Model of Groupware. In *Proceedings of the 1994 Conference on Computer Supported Cooperative Work*. Chapel Hill NC: ACM Press, 79-88.

Elofson, G., & Konsynski, B. (1991). Delegation Technologies: Environmental Scanning with Intelligent Agents. *Journal of Management Information Systems*, 8(1), 37-62.

Engeström, Y., Engeström, R., & Saarelma, O. (1988). Computerized Medical Records, Production Pressure and Compartmentalization in the Work Activity of Health Center Physicians. In Proceedings of the 1988 Conference on Computer Supported Cooperative Work. *Portland: ACM Press, 65-84.*

Eveland, J., Blanchard, A., Brown, W., & Mattocks, J. (1994). The Role of 'Helpnetworks' in Facilitating Use of CSCW Tools. In *Proceedings of the 1994 Conference on Computer Supported Cooperative Work*. Chapel Hill NC: ACM Press, 265-274.

Fagrell, H., & Ljungberg, F. (1999). Exploring Support for Knowledge Management in Mobile Work. In S. Bødker, M. Kyng, & K. Schmidt (Eds.), *Proceedings of the 6th European Conference on Computer Supported Cooperative Work (ECSCW'99)*. Copenhagen: Kluwer Academic Publishers, 259-275.

Flores, T., Graves, M., Hartfield, B., & Winograd, T. (1988). Computer Systems and the Design of Organizational Interaction. *ACM Transactions on Office Information Systems*, 6(2), 153-172.

Franz, C., & Robey, D. (1987). Strategies for Research on Information Systems in Organizations: A Critical Analysis of Research Purpose and Time Frame. In R. Boland, Jr. & R. Hirschheim (Eds.), *Critical Issues in Information Systems Research*. John Wiley & Sons, 205-225.

Gantt, M., & Nardi, B. (1992). Gardeners and Gurus: Patterns of Co-operation among CAD Users. In *Proceedings of CHI'92*, Monterey, CA, 107-117.

Grudin, J. (1989). Why Groupware Applications Fail: Problems in Design and Evaluation. *Office: Technology and People*, 4(3), 245-264.

Grønbæk, K., & Mogensen, P. (1997). Informing General CSCW Product Development through Cooperative Design in Specific Work Domains. *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, 6(4), 275-304.

Harper, R. (1997). Towards the Paperless Hospital? A Study of Document Use by Anaesthetists. *British Journal of Anaesthesia,* 78, 762-767.

Harper, R. (1998). *Inside the IMF: An Ethnography of Documents, Technology, and Organisational Action*. San Diego: Academic Press.

Harper, R. (2000). The Organisation in Ethnography. *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, 9(2), 239-264.

Harper, R., Hughes, J., & Shapiro, D. (1989). Working in Harmony: Examination of Computer Technology in Air Traffic Control. In *Proceedings of the First European Conference on Computer Supported Cooperative Work (ECSCW'89)*. Gatwick: Kluwer Academic Publishers, 73-87.

Heath, C., & Luff, P. (1991). Collaborative Activity and Technological Design: Task Coordination in London Underground Control Rooms. In L. Bannon, M. Robinson, & K. Schmidt (Eds.), *Proceedings of the 2nd European Conference on Computer Supported Cooperative Work (ECSCW'91)*. Amsterdam: Kluwer Academic Publishers, 65-80.

Heath, C., & Luff, P. (1996a). Documents and Professional Practice: 'Bad Organisational Reasons for "good" Clinical Records. In *Proceedings of the 1996 Conference on Computer Supported Cooperative Work*. Boston: ACM Press, 354-363.

Heath, C., & Luff, P. (1996b). Convergent Activities: Line Control and Passenger Information on the London Underground. In Y. Engeström & D. Middleton (Eds.), *Cognition and Communication at Work*. Cambridge: Cambridge University Press, 96-129.

Hirschheim, R. (1985). *Office Automation – A Social and Organizational Perspective.* Chichester New York: John Wiley.

Huber, G. (1991). Organizational Learning: The Contributing Processes and the Literatures, *Organization Science*, 2(1), 88-115.

Hughes, J., Randall, D., & Shapiro, D. (1992). Faltering from Ethnography to Design. In *Proceedings of the 1992 Conference on Computer Supported Cooperative Work*. Toronto: ACM Press, 115-122.

Hughes, J., Randall, D., & Shapiro, D. (1993). From Ethnographic Record to System Design: Some Experiences from the Field. *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, 1(3), 123-141.

Huhns, M., Mukhopadhyay, U., Stevens, L., & Bonnell, R. (1989). DAI for Document Retrieval: MINDS Project. In L. Gasser, & M.N. Huhns (Eds.), *Distributed Artificial Intelligence*. San Mateo CA: Morgan Kauffman, 249-283.

Hutchins, E., & Klausen, T. (1996). Distributed Cognition in an Airline Cockpit. In Y. Engeström & D. Middleton (Eds.), *Cognition and Communication at Work*. Cambridge: Cambridge University Press, 15-34.

Karahanna, E., Straub, D., & Chervany, N. (1999). Information Technology Adoption Across Time: A Cross-Sectional Comparison of Pre-Adoption and Post-Adoption Beliefs. *MIS Quarterly*, 23(2), 183-213.

Karsten, H., & Jones, M. (1998). The Long and Winding Road: Collaborative IT and Organisational Change. In *Proceedings of the 1998 Conference on Computer Supported Cooperative Work*. Seattle: ACM Press, 29-38.

Kensing, F., & Blomberg, J. (1998). Participatory Design: Issues and Concerns. *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, 7(3/ 4), 167-185.

Kim, D. (1993). The Link Between Individual and Organizational Learning. *Sloan Management Review*, (Fall:1993), 37-50.

Kling, R. (1991). Cooperation, Coordination and Control in Computer Supported Work. *Communications of the ACM*, 34(12), 83-88.

Kolb, D. (1984). *Experiential Learning, Experience as The Source of Learning and Development*. Englewood Cliffs NJ: Prentice-Hall.

Konda, S., Monarch, I., Sargent, P., & Subrahmanian, E. (1992). Shared Memory in Design: A Unifying Theme for Research and Practice. *Research in Enginering Design*, 4, 23-42.

Kuutti, K., & Arvonen, T. (1992). Identifying Potential CSCW Applications by Means of Activity Theory Concepts: A Case Example. In *Proceedings of the 1992 Conference on Computer Supported Cooperative Work*. Toronto: ACM Press, 233-240.

Kyng, M. (1991). Designing for Cooperation: Cooperating in Design. *Communications of the ACM*, 34(12), 64-73.

Kyng, M. (1995). Making Representations Work. *Communications of the ACM*, 38(9), 46-55.

Levitt, B., & March, J. (1988). Organizational Learning. *Annual Review of Sociology*, 14(3), 319-340.

Litiu, R., & Parakash, A. (2000). Developing Adaptive Groupware Applications Using a Mobile Component Framework. In *Proceedings of the 2000 Conference on Computer Supported Cooperative Work*. Philadelphia: ACM Press, 107-116.

Lotus Development Corporation Ltd. (1995). *Groupware, Communication, Collaboration and Coordination*. www.lotus.com.

Luff, P., & Heath, C. (1998). Mobility in Collaboration. In *Proceedings of the 1998 Conference on Computer Supported Cooperative Work*. Seattle: ACM Press, 305-314.

Lynch, K., & Chen, H. (1992). Knowledge Discovery from Historical Data: An Algorithmic Approach. In J. Nunamaker (Ed.), *Proceedings of the 25th Hawaii International Conference on System Sciences (HICSS'92)*. Los Alamitos CA: IEEE Computer Society Press, 3, 70-79.

Lyytinen, K. (1989). *Computer Supported Co-operative Work (CSCW) - Issues and Challenges*. Technical Report, Department of Computer Science, Jyväskylä: University of Jyväskylä.

Lyytinen, K., & Ngwenyama, O. (1997). Groupware Environments as Action Constitutive Resources: A Social Action Framework for Analyzing Groupware Technologies. *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, 6(1), 71-93.

Mackay, W.E. (1990). Patterns of Sharing Customizable Software. In Proceedings of the 1990 Conference on Computer Supported Cooperative Work. *Los Angeles: ACM Press, 209-221.*

Malone, T., & Crowstone, K. (1990). What is Coordination Theory and How Can It Help Design Cooperative Work Systems?. In Proceedings of the 1990 Conference on Computer Supported Cooperative Work. *Los Angeles: ACM Press, 357-370.*

Malone, T., Lai, K-Y., & Fry, C. (1992). Experiments with Oval: A Radically Tailorable Tool for Cooperative Work. In *Proceedings of the 1992 Conference on Computer Supported Cooperative Work*. Toronto: ACM Press, 289-297.

Mark, G., & Bordetsky, A. (1998). Structuring Feedback for Groupware Use: Memory-Based Awareness. In R.H. Sprague, Jr. (Ed.), *Proceedings of the 31nd Hawaii International Conference on System Sciences (HICSS'98)*. Los Alamitos CA: IEEE Computer Society Press.

Mathiassen, L. (1987). Systems, Processes, and Structures: A Contribution to the Theoretical Foundation of Information Systems Development and Use. *System Design for Human Development and Productivity: Participation and Beyond*. Amsterdam: Elsevier North-Holland, 49-61.

McDonald, D., & Ackerman, M. (1998). Just Talk to Me: A Field Study of Expertise Location. In *Proceedings of the 1998 Conference on Computer Supported Cooperative Work*. Seattle: ACM Press, 315-324.

Michelis, G., Dubois, E., Jarke, M., Matthes, F., Mylopoulos, J., Schmidt, J., Woo, C., & Yu, E. (1998). A Three-Facet Information. *Communications of the ACM*, 41(12), 64-70.

Moran, T., Melle, W., & Chiu, P. (1998). Tailorable Domain Objects as Meeting Tools for an Electronic Whiteboard. In *Proceedings of the 1998 Conference on Computer Supported Cooperative Work*. Seattle: ACM Press, 295-304.

Nonaka, I., & Takeuchi, H. (1995). *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford: Oxford University Press.

Norros, L. (1996). System Disturbances as Springboard for Development of Operators' Expertise. In Y. Engeström & D. Middleton (Eds.), *Cognition and Communication at Work*. Cambridge: Cambridge University Press, 159-176.

Nunamaker, J.F., Chen, M., & Purdin, T. (1991b). Systems Development in Information Systems Research. *Journal of Management Information Systems*, 7(3), 89-106.

Nunamaker, J., Dennis, A., & Valacich, J. (1991a). Electronic Meeting Systems to Support Group Work. *Communications of the ACM*, 34(7), 40-61.

Okamura, K., Fujimoto, M., Orlikowski, W.J., & Yates, J. (1994). Helping CSCW Applications Succeed: The Role of Mediators in the Context of Use. In *Proceedings of the 1994 Conference on Computer Supported Cooperative Work*. Chapel Hill NC: ACM Press, 55-65.

Orlikowski, W. (1992). Learning from Notes: Organizational Issues in Computer Mediated Communication. In *Proceedings of the 1992 Conference on Computer Supported Cooperative Work*. Toronto: ACM Press, 362-369.

Paunonen, H. (1997). *Roles of Informating Process Control Systems*. PhD Dissertation. Publications 225, Tampere: University of Technology.

Rao, V., & Goldman-Segall, R. (1995). Capturing Stories in Organizational Memory Systems: The Role of Multimedia. In R.H. Sprague, Jr. (Ed.), *Proceedings of the 28th Hawaii International Conference on System Science (HICSS'95)*. Los Alamitos CA: IEEE Computer Society Press, 333-341.

Robinson, M. (1991). Double Level languages and Co-operative Working. *AI&Society*, 5, 34-60.

Rogers, Y. (1994). Exploring Obstacles: Integrating CSCW in Evolving Organizations. In *Proceedings of the 1994 Conference on Computer Supported Cooperative Work*. Chapel Hill NC: ACM Press, 67-77.

Sandoe, K., & Mandviwalla, M. (1991). Meeting in Time: Recording the Workgroup Conversation. In *Proceedings of the 12th International Conference on Information Systems*. New York, 261-271.

Sandoe, K., & Olfman, L. (1992). Anticipating the Mnemonic Shift: Organizational Remembering and Forgetting in 2001. In *Proceedings of the 13th International Conference on Information Systems*. Dallas, 127-137.

Schmidt, K., & Bannon, L. (1992). Taking CSCW Seriously: Supporting Articulation Work. *Computer Supported Cooperative Work (CSCW)*, 1(1-2), 7-40.

Schmidt, K., & Simone, C. (1996). Coordination Mechanisms: Towards a Conceptual Foundation of CSCW Systems Design. *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, 5(2/3), 155-200.

Shapiro, D. (1994). The Limits of Ethnography: Combining Social Sciences for CSCW. In *Proceedings of the 1994 Conference on Computer Supported Cooperative Work*. Chapel Hill NC: ACM Press, 417-428.

Smith, G., & O'Brien, J. (1998). Re-Coupling Tailored User Interfaces. In *Proceedings of the 1998 Conference on Computer Supported Cooperative Work*. Seattle: ACM Press, 237-246.

Star, S., & Griesemer, J. (1989). Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology. *Social Studies of Science*, 19, 387-420.

Stein, E. (1995a). Organizational Memory: Review of Concepts and Recommendations for Management. *International Journal of Information Management*, 15(2), 17-32.

Stein, E. (1995b). Actualising Organizational Memory with Information Systems. *Information Systems Research*, 6(2), 85-117.

Suchman, L. (1987). *Plans and Situated Actions: The Problem of Human-Machine Communication*. Cambridge: Cambridge University Press.

Suchman, L. (1995). Making Work Visible. *Communications of the ACM*, 38(9), 56-64.

Suchman, L. (1996). Constituting Shared Workspaces. In Y. Engeström & D. Middleton (Eds.), *Cognition and Communication at Work*. Cambridge: Cambridge University Press, 35-59.

Teege, G. (2000). Users as Composers: Parts and Features as a Basis for Tailorability in CSCW Systems. *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, 9(1), 101-122.

Terveen, L., Selfridge, P., & Long, M. (1993). From 'Folklore' to 'Living Design Memory'. In *ACM 1993 Conference Proceedings on Human Factors in Computing Systems*. Amsterdam, 15-22.

Trigg, R., & Bødker, S. (1994). From Implementation to Design: Tailoring and the Emergence of Systematization in CSCW. In *Proceedings of the 1994 Conference on Computer Supported Cooperative Work*. Chapel Hill NC: ACM Press, 45-54.

Tuomi, I. (1996). The Communicative View on Organizational Memory: Power and Ambiguity in Knowledge Creation Systems. In R.H. Sprague, Jr. (Ed.), *Proceedings of the 29th Hawaii International Conference on System Science (HICSS'96)*. Los Alamitos CA: IEEE Computer Society Press, 147-155.

Turner, J. (1987). Understanding the Elements of System Desing. In R. Boland & R. Hirschheim (Eds.), *Critical Issues in Information Systems Research*. John Wiley & Sons, 97-111.

Walsh, J., & Ungson, G. (1991). 'Organizational Memory'. *Academy of Management Journal*, 16(1), 57-91.

Winograd, T. (1987). *A Language-Action Perspective on the Design of Cooperative Work*. Department of Computer Science. STAN-CS-87-1158, Stanford: Stanford University.

YHTEENVETO (FINNISH SUMMARY)

Tämä tutkimus on ollut yli seitsemän vuoden vaellus ideoiden viidakosta ja mahdollisuuksien maailmasta kaupalliseksi ohjelmistotuotteeksi. Tutkimustyön taustat ulottuvat 1990-luvun alkupuolelle, jolloin erilaiset organisaatiot pyrkivät uudelleenmuotoilemaan rakenteitaan enemmän ihmisten välistä yhteistyötä tukeviksi vuorovaikutteisiksi työryhmiksi – tiimeiksi. Samoihin aikoihin tapahtui myös uusien internet -pohjaisten teknologioiden läpimurto. Tietojärjestelmien tutkimuksessa nämä kehityspolut yhdistyivät tutkimusalueiden CSCW (Computer Supported Cooperative Work) ja Groupware – yhteistyön tietokonetuki – alle. Tutkijoiden uusi haaste oli, kuinka toisistaan usein valitettavankin kaukana olevat lähestymistavat (ihminen, yhteistyö, teknologia) kyettäisiin joustavasti niveltämään yhteen. Tämä organisaatioiden ja teknologian kehityksessä tapahtunut murros toi teknologiaa liiketoiminnassaan hyödyntävälle teollisuudelle uusia mahdollisuuksia hakea parempia kilpailuasemia, teknologioita tuottavalle ohjelmistoteollisuudelle uusia liiketoimintamahdollisuuksia sekä tutkimukselle mielenkiintoisia ja usein poikkitieteellisiä tutkimusaihioita. Näistä lähtökohdista ja teollisuuden aloitteesta käynnistettiin syksyllä 1993 Jyväskylän yliopiston koordinoimat ja TEKES:in tavoitetutkimushankkeina organisoidut soveltavan tutkimuksen projektit. Niissä joukko suomalaisia teollisuusyrityksiä halusi yhdessä tutkijoiden kanssa testata uutta lupaavaa teknologiaa sekä kehittää kommunikaatiota ja tiedonjakamista edistäviä työkaluja.

Yhdeksi tutkimuskohteeksi – yhteistyössä teollisten kumppaneiden kanssa - määriteltiin vuorotyönä (24/7) tapahtuva teollisen tuotantoprosessin välitön prosessinohjaus. Tässä työssä pyrin tarkastelemaan erityisesti siihen kohdistuvaa tutkimuslähtöistä ohjelmistokehitysprosessia, jossa tutkimuksen rooli on tarvittaessa ohjata tai tukea varsinaista ohjelmiston kehittämistä. Tutkimustyön perustana oli pyrkimys kehittää teknologiaa ’ihmisläheisesti’, käyttäjien tarpeista lähtien, teknologia taustalla pitäen. Tämä asetti kehittämisprosessissa sovellettaville menetelmille joukon erityisvaatimuksia. Poikkitieteellistä lähestymistapaa korostaen tutkimusryhmässä oli mukana myös sosiologian ja viestinnän tutkijoita.

Alustavien empiiristen tutkimustulosten perusteella huomasimme, että organisaation muisti muodosti parhaan kehyksen kuvaamaan sitä mitä olimme kehittämässä. Havaitsimme myös, että aiempi CSCW –tutkimus tuki kaupalliseen hyödyntämiseen tähtäävien ohjelmistojen kehittämistä varsin heikosti. Tutkimusalueen elinvoimaisuuden kannalta on kuitenkin olennaista, että se kykenee luomaan pohjaa myös kaupallisesti menestyvien ohjelmistotuotteiden kehittämiselle. Tässä tutkimustyössä raportoin kokemuksiamme tutkimuksen roolista ohjelmistokehitysprosessissa ja tuon uudenlaista näkökulmaa prosessiin, jossa tutkimusideasta jalostetaan kaupallisesti menestyvää ohjelmistotuotetta.

Tutkimustyön keskeinen kysymys oli: *'kuinka prosessinohjauksen tiedonjakamista ja kommunikaatiota tehostetaan tietokonesovellusten avulla?'*. Tutkimuksen aikana tämä tarkentui seuraaviksi teemoiksi: kuinka tunnistetaan kehittämiskohteeksi parhaiten soveltuvat työprosessit, kuinka nämä prosessit voidaan kuvata ja esittää sekä muovata tietokonesovelluksen muotoon, sekä kuinka sovelluksen kehittäminen tapahtuu ja kuinka sovellusta hyödynnetään organisaatioissa. Näiden selvittämiseksi tehtiin joukko toisiaan tukevia tutkimuksia, joiden keskeiset tulokset raportoidaan tässä opinnäytteessä itsenäisissä, mutta toisiinsa kytköksissä olevissa julkaisuissa. Kaikkia tutkimuksia yhdistävä piirre oli, että kukin niistä palveli ohjelmiston kehittämistä omalla näkökulmallaan.

Tutkimuksen tavoitteet tarkentuivat kehittämisprosessin edetessä ja ryhmittyivät tieteellisiin, konstruktiivisiin ja empiirisiin tavoitteisiin. Tieteellisenä tavoitteena oli löytää ja määritellä prosessinohjauksen tietokonetuettua yhteistyötä parhaiten kuvaavat käsitteet. Konstruktiivisina tavoitteina oli kehittää prosessinohjauksen tiedonjakamista ja kommunikaatiota tukevia ohjelmistosovelluksia, arvioida tutkimuslähtöistä ohjelmistokehitystä, sekä tunnistaa CSCW -sovellusten kaupallistamisen keskeiset lähtökohdat. Empiirisinä tavoitteina oli määritellä prosessinohjauksen yhteistön tyypilliset piirteet ja kehittämiskohteet. Erityisesti tutkimustyössä pyrittiin selvittämään organisaation muistin roolia prosessinohjauksessa.

Tutkimuksessa sovellettiin konstruktiivista eli kokeilevaa lähestymistapaa, jolla pyritiin testaamaan erilaisten tutkimusmenetelmien soveltumista ohjelmistokehitykseen. Tutkimuksessa hyödynnettiin erityisesti osallistuvan systeemityön menetelmiä, jossa todelliset käyttäjät pyrittiin niveltämään kehitystyöhön mukaan heti projektin alusta lähtien. Perinteisten menetelmien kuten haastattelujen, seinätaulutekniikan ja prototyyppilähestymistavan lisäksi käytettiin myös aivoriihitekniikkaa (*brainstorming*). Tutkimustulosten kannalta erityisen merkittävä rooli oli kuitenkin etnografisten tutkimusmenetelmien soveltamisella ohjelmistokehitykseen. Niiden lähtökohta on alunperin antropologisessa tutkimuksessa, jossa menetelmien avulla on pyritty selvittämään esimerkiksi ihmisten käyttäytymistä tutkijalle vieraissa ympäristöissä. Etnografisten menetelmien hyödyntäminen ohjelmistokehityksessä on toistaiseksi ollut vähäistä. Tutkimuksessa sovellettujen menetelmien haasteena oli saada työprosessit ja erityisesti ihmisten välinen vuorovaikutus läpinäkyväksi ja siten muovailtavaksi tietokoneohjelmiston muotoon.

Empiirisissä tutkimuksissa havaittiin, että organisaation kyvykkyydellä hallita aiempiin tapahtumiin ja kokemuksiin liittyvää tietämystä on keskeinen rooli tuotantoprosessin hallinnassa. Vuoronvaihdot ja työntekijöiden sijoittuminen toisistaan erillään oleviin valvomoihin aiheuttavat usein katkoksia tiedon jakamisessa. Lisäksi häiriötilanteet käynnistävät prosessinohjauksessa kiireellisiä tiedonjakamisen ja kommunikaation tarpeita. Valitettavasti häiriötilanteissa kipeimmin tarvittava osaaminen ei kuitenkaan aina ole käytettävissä. Vuoron keskeiset tapahtumat saattavat myös jäädä vain yksittäisten työntekijöiden muistiin. Tiedonjakamista korostava organisaatiokulttuuri ja työn organisointi ovat eräitä keinoja, joilla organisaatiot pyrkivät tehostamaan toiminnan kannalta oleellisen tiedon välittymistä. Näiden lisäksi organisaatiot ovat kehit-

täneet käyttöönsä joukon erilaisia tiedonjakamista tukevia työkaluja (*artifakteja*). Näistä erityisesti vuoropäiväkirja toimii organisaation muistina, johon pyritään dokumentoimaan vuoron keskeiset tapahtumat. Perinteisesti vuoropäiväkirjamerkinnät on tehty käsin vihkoon kirjoittaen, jolloin ne ovat samanaikaisesti luettavissa vain yhdessä paikassa, yleensä vuoromestarin valvomossa. Lisäksi samasta tapahtumasta saattaa olla useita eri työpisteissä sijaitsevia kirjauksia, jolloin kokonaiskuvan saaminen tilanteesta vaatii eri kirjausten tarkistamista ja yhdistämistä. Tässä tutkimuksessa pyrittiin kehittämään ohjelmistosovellus, jolla vuoron keskeiset tapahtumat saataisiin paremmin näkyville ja näin koko organisaation hyödynnettäväksi ajasta ja paikasta riippumatta.

Tutkimuksen tuloksena kehitetyn ja myös kaupallisesti saatavilla olevan ohjelmistosovelluksen havaittiin parantavan vuorojen välistä kommunikointia sekä koko tuotantolinjan työntekijöiden tietoisuutta tuotantoprosessin tilasta. Yhä useammat työntekijät seurasivat aktiivisesti vuoron keskeisiä tapahtumia. Kehitetty sovellus muutti aiemmin passiiviset vuoropäiväkirjan kirjaukset vuorovaikutteisiksi prosesseiksi: sovelluksen kautta käytiin vilkkaitakin keskusteluja ajankohtaisten tapahtumien ympärillä. Organisaation muisti ei siten ollut enää pelkästään passiivinen tietovarasto, vaan pikemminkin ohjelmiston tukema dynaaminen prosessi, joka loi osaltaan pohjaa myös organisaation oppimiselle. Lisäksi sovellus vapautti työntekijät aika-paikkasidonnaisuudesta, koska kirjauksia ei tarvinnut enää käydä lukemassa tietystä työpisteestä, vaan niitä kyettiin selailemaan tosiaikaisena suoraan omalta työasemalta. Tutkimuksessa tunnistettiin lisäksi vuoropäiväkirjaohjelmiston keskeiset suunnitteluperiaatteet sekä ohjelmiston kriittiset menestystekijät.

Tutkimuksessa havaittiin, että tutkimuslähtöisessä ohjelmistokehityksessä menetelmien käytön tulee olla joustavaa siten, että kunkin ohjelmistokehitysvaiheen erityispiirteet otetaan erikseen huomioon. Perinteinen tutkimusasetelma, jossa metodien ja menetelmien käyttö on tarkoin etukäteen määriteltyä soveltuu sangen huonosti tämän kaltaiseen kehitystyöhön. Etnograafiset tutkimusmenetelmät yhdistettynä osallistuvan systeemityön menetelmiin havaittiin erityisen käyttökelpoisiksi tutkimuslähtöisen ohjelmistokehityksen välineiksi. Osallistuvan systeemityön menetelmät edistivät eri sidosryhmien sosiaalista integroimista kehitysprosessiin, mikä tuki myöhemmin tapahtuvaa ohjelmistosovelluksen teknistä integrointia. Teknisessä integroinnissa tulee ottaa huomioon sovelluksen liittäminen tai upottaminen käyttöorganisaation tietoarkkitehtuuriin jo mahdollisemman varhaisessa kehittämisvaiheessa. Sovellusta joudutaan usein myös räätälöimään erilaisten käyttäjien tarpeiden mukaisesti. Tällöin tulee kiinnittää huomiota muun muassa siihen, kuinka pitkälle sovelluksen toimintoja standardoidaan tai kuinka paljon käyttäjälle annetaan toimintavapautta. Esimerkiksi vuoropäiväkirjan kirjaustavan standardoinnilla voidaan pyrkiä rajoittamaan muutoin kirjavaa kirjauskäytäntöä. Liiallisen standardoinnin vaarana on kuitenkin, että käyttäjä kokee kirjausten tekemisen liian hankalaksi ja siksi saattaa jopa lopettaa koko sovelluksen käytön. Sovellusten räätälöinti ja jatkokehitys tapahtuu usein ’ulkopuolisten’ ohjelmistotalojen toimesta. Osallistuvan systeemityön menetelmät sopivat hyvin myös ohjelmiston koko elinkaaren aikana tapahtuvaan kehittämistyöhön.

Tutkimuksen tuloksena kehitetty kaupallinen ohjelmistosovellus on käytössä jo useissa energialaitoksissa, paperi- ja sellutehtailla sekä jätevedenpuhdistamoilla. Lisäksi se toimii erään kansainvälisen konsernin prosessinohjauksen tietämyshallinnan alustana. Prosessiteollisuuden järjestelmätoimittaja soveltaa tutkimustuloksia omissa ohjelmistotuotteissaan. Paperikonevalmistaja hyödyntää vuoropäiväkirjaa paperitehtaan käyntiinajovaiheen tapahtumatiedon raportoinnissa. Tutkimuksessa kehitetty ohjelmistosovellus tarjoaa siten lisäarvoa useisiin paperi- ja selluteollisuuden liiketoimintaketjun eri osa-alueisiin. Tutkimustuloksia voidaan soveltaa myös kehitettäessä uusia tiedonjakamista ja kommunikaatiota edistäviä ominaisuuksia olemassa oleviin tai tulevaisuuden prosessinohjausjärjestelmiin. Ohjelmistosovelluksen muita potentiaalisia käyttöympäristöjä ovat mm. kemianteollisuus, terästeollisuus, kriisien hallinta, sairaalat, poliisi- ja pelastuspalvelut, sekä puhelinpalvelu (call-center) -yksiköt.

Mielenkiintoisena uutena tutkimusaiheena CSCW-kirjallisuudessa on esitetty, kuinka työntekijöiden liikkuvuutta voitaisiin paremmin tukea tietotekniikan keinoin. Olemme jälleen uuden murroksen kynnyksellä, jossa haetaan uusia tapoja organisoida työntekijöiden liikkuvuutta langattoman viestintäteknologian tuomia mahdollisuuksia hyödyntäen. Tähän soveltuvia päätelaitteita on runsaasti tarjolla, mutta käyttökelpoisia sovelluksia on edelleen niukasti. Lähtökohdat ovat samankaltaiset, kuin mitkä ne olivat käynnistettäessä tähän opinnäytteeseen johtanutta tutkimusprojektia. Tässä tutkimuksessa kuvatut tutkimuslähtöisen ohjelmistokehityksen periaatteet saattaisivat avata aivan uusia näkökulmia myös liikkuvan työyhteisön tarpeisiin soveltuvien ohjelmistosovellusten kehittämiseen.

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